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''A Decision Model to select the best Indian city to be targeted for Solar Panel business for industrial use''

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ABSTRACT

Nowadays, there is growing trend in implementing different 'green initiatives' in industries. One of those initiatives is maximizing use of renewable sources of energy instead of traditional energy sources. Many industries in India are taking a step forward to use the environment friendly sources of energy like solar energy, wind energy, tide energy etc. The most important source is solar energy. To convert solar energy into electrical energy, solar panels are required. Because of increasing demand in solar panels, many small scale and mid-scale Indian companies are planning to start 'solar panel installation' business for industries. For such companies, it is necessary to identify the target market to maximize the total sale. This paper gives a decision model to help such company to identify their target customer city.

Number of factors affect any decision-making process and the final decision. For this paper, a four-level decision model is built with decision problem, four main criteria and nine sub-criteria and alternatives. For the scope of this paper, three major metro cities in India are considered as possible choices for final decision. Those cities are alternatives in the model. Hierarchical Decision Modelling which is known as HDM is the methodology used in this paper to evaluate all the alternatives against all criterial and sub-criteria. HDM online tool is used to take expert's opinion and evaluation. Five related topic experts are asked for their judgements. With the result analysis and sensitivity analysis, 'Delhi' is the city chosen towards final decision.

While this model helps to make a sound decision, still there are some opportunities to expand the same model to make it more inclusive. The decision could be made more robust by including experts for specific criteria. More cities could be added as alternatives. Similarly, more criteria and sub-criteria can be added as per the company's requirements.

INTRODUCTION

India is one amongst the fastest growing countries in the world [1]. According to the International Monetary Fund organization, GDP (Gross Domestic Product) is one of the factors which gives an indication about country's economic growth [2]. As per the latest statistical reports, India is one of the top countries with high GDP [3] and the growth rate is going to be accelerated in future to achieve better ranking [3]. There is no doubt that Energy is playing central role in achieving India's development ambitions and to support expanding economy [1]. India's energy consumption is doubled since 2000 and the rapid economic growth is in need for more energy requirements.

Traditionally, the country was dependent on the non-renewable sources of energy. Coal, fuelwood, oil are some of the types with which the energy used to be generated [1]. But India has stepped up in the deployment of renewable sources of energy [1]. 'India is in the sunny regions of the world with most parts of the country receiving 4-7wh (kilowatt-hour) of solar radiation per square meter per day 250-300 sunny days in a year' [5]. This factor is the most important factor which is attracting many industries, companies and even common people to adopt solar energy products. In 2017, India is ready to become fourth largest solar market globally [4]. This clearly shows that there is a huge potential for the solar market business in India. In addition to the well-established big companies, many small companies, entrepreneurs, educational institutes have started investing in solar projects.

But, how exactly the solar energy is useful? Below figure shows the basics of how the solar energy is used.

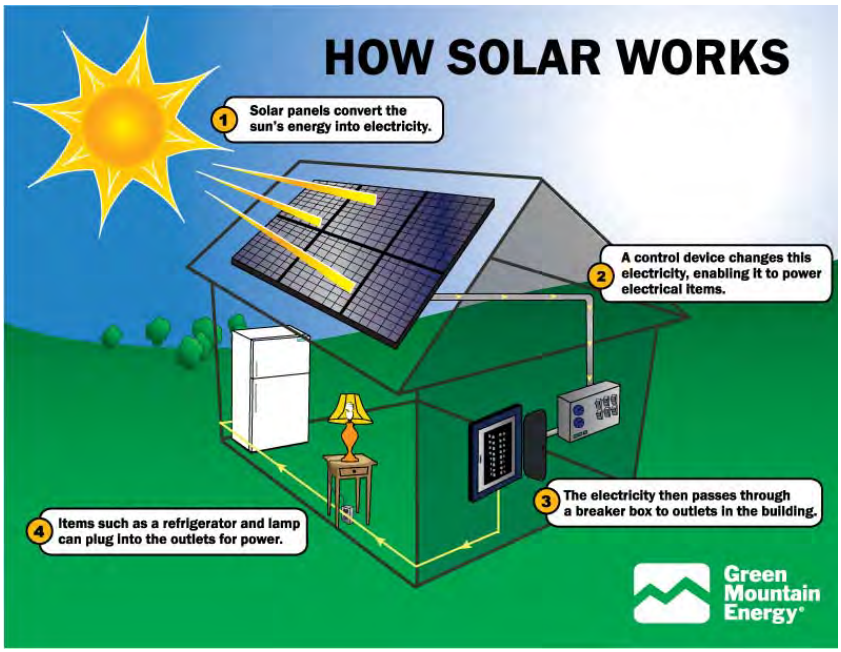

Fig 1. Solar energy functioning [6]

As shown in the figure, the solar panels convert solar energy into electricity and then that electricity can be used to run different appliances either in residential home or industry.

Solar panel is the most important element in this solar system. Nowadays, many small, medium, large industries are planning to install solar panels and try to use the solar energy as a source to generate electricity. Generally, for industries, large number of solar panels are required depending on their energy needs. Below figure shows the work in progress for 'solar panel installation' for one of the industries.

Fig. 2 Solar Panels for industries [7]

Even the Indian government has started taking serious considerations in solar energy projects. The government policies are leaning towards solar energy projects. Solar power is a key element of the government's expansion plans [1]. Government has launched the Jawaharlal Nehru National Solar Mission in 2010. The mission is upgraded in 2014 as 100 GW of solar installations by 2022, 40 GW of rooftop solar photovoltaics (PV) and 60 GW of large- and medium-scale grid-connected PV projects [1].

This clearly shows the large potential market for solar industries in India. To get the advantage of this situation, there are many companies planning to enter solar market and make profit. For such companies, it is very important to decide the market to be targeted in terms of territory. Particularly, for the start-up company, it is convenient to focus on specific state or city so that it is easier for them to do marketing activities and sell their product. In this paper, the decision model is created to help such businesses. The model can be used as a tool to make a final decision of deciding which city to be targeted for solar panel business.

METHODOLOGY

Infinite number of decision are taken in day to day life. The outcome of any decision impacts on various elements such as a person's career path, person's financial condition etc. The severity of the outcome of any decision depends upon the complexity of that decision. Particularly, in professional life, the decision of high-level managers, c-suit executives, directors can affect the company's future. And that is why making sound decision is very important. There are some tools, techniques, methodologies which can help a decision maker to evaluate

possible options, their probabilities, their impacts. HDM is one of those tools, which is used in this paper to support the decision making of 'selection of city'.

Hierarchical Decision Making (HDM):

Thomas L. Saaty developed a decision-making technique in 1970s which is known as Analytical Hierarchical Model (AHP) [8]. The model consists of different hierarchy levels with goals, criteria, sub-criteria and alternatives. Pairwise comparison is done to measure relative importance of elements of each level. And the best alternative is selected after evaluating all possible alternatives against the different factors. Basically, AHP helps decision maker to convert subjective judgement to objective measures [9]. In around 1980s, Dr. Kocaoglu and Cleland introduced a new refined methodology called HDM, which stand for Hierarchical Decision Model [9]. This paper uses HDM methodology to make the decision.

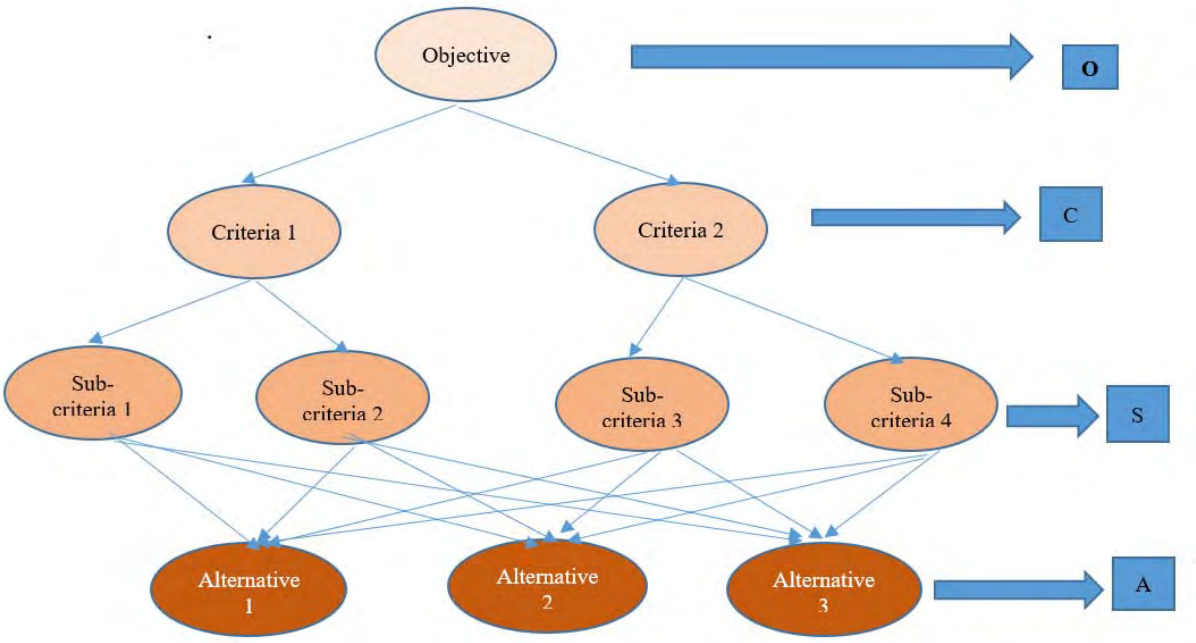

Fig 3. Generalize HDM model for this paper

The above figure 3 shows the basic HDM model [9]. The number of levels can vary depending on the decision to be made. The mesh structure signifies the relativity of each element with other relative elements. The top level is the main decision to be made, followed by criteria and sub-criteria. A pairwise comparison is made for all elements on each level. For this step of pairwise comparison, identifying experts is the predecessor task. And this task is significantly important because all the successive calculations depend on the expert's opinions (In terms of numbers) The bottom level consists of the alternatives, meaning possible solutions. Then by using the mathematical formula, relative weightages can be calculated for each alternative. Those weightages are used in final decision making. Below formula is used to find the final weightages.

In summation, the HDM tool helps to convert qualitative data (extracted from experts' judgements) to quantitative data (final weightages in numbers). The mathematical formula used [10] to find the final weighted average for an alternative for the above model of the paper is

$$\sum_{i=1}^{I} C_i \sum_{j=1}^{J} S_j \sum_{k=1}^{K} A_k = W$$

Where,

W= Aggregate score of the decision (sum to unity)

C_i = Relative contribution of criteria to the decision

S_j = relative contribution of the sub-criteria for the criteria

A_k = Relative contribution of alternative to the decision

I = number of criteria

J = Number of sub-criteria for that criteria

K = Number of alternatives

The online HDM tool is developed by Engineering and Technology (ETM) department at Portland State University (PSU). This tool helps the decisionmaker to use HDM model easily and effectively. It helps expert to put their expert judgements directly online. In addition to that the tool helps to do final calculations for weightages. It also calculates the inconsistency in the judgments of any expert or disagreement amongst the experts. This paper uses the online HDM tool for decision making.

DATA AND DATA SOURCE(S)

Data used:

When it comes to selecting a best city for solar panel business, number of criteria need to be considered. Political, economic, Social, Environmental, Technical are some of the factors which play important role in decision making. For this paper, four main criteria are selected namely weather, infrastructure, economic and social. Also, for each criterion, some sub-criteria are considered. There are some other criteria and sub-criteria those could be added in the model, but the most important ones are selected for this paper.

Below are the details of all the criteria and sub-criteria.

A) Weather

For solar panels installation, weather is the most inevitable factor to be considered. More quality sunlight means more useful the solar panels are. India has the potential sun-light throughout the year that can be used for energy conversion. Below graph shows the how the sunlight is dispersed over the world.

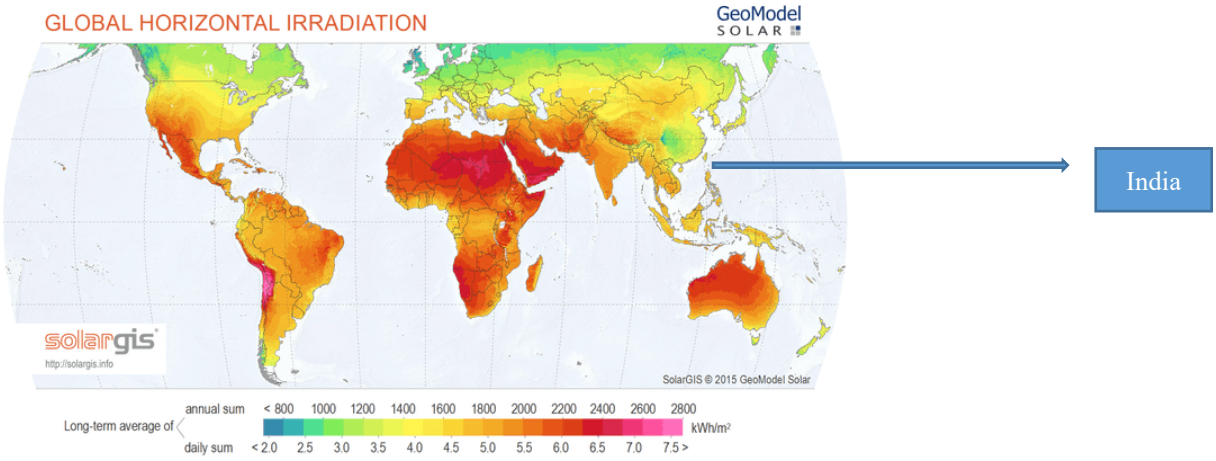

Fig 4. Global horizontal irradiation [11]

So, overall, the weather is quite good for solar panels in India. But the 'weather' criteria will decide what experts think about it and how important it is than other criteria.

Under the criteria of 'weather', two sub-criteria are listed.

a) Availability of sunlight: As discussed above, 'how important it is to have sun available' is one of the things need be analyzed before selecting the city. In India, the solar energy is dispersed and not constant throughout. Every state differs in solar intensity [12].

b) Bad weather period: Sometimes, bad weather can affect the solar panel working negatively. For example, high wind, heavy rain can damage the solar panel. So, this 'bad weather' factor should also be considered.

Now, under weather criteria, experts are asked about what is the important factor for them for doing solar panel business, is it good weather (availability of sun) or bad weather.

B) Infrastructure:

In case of solar panel business, the activities include installing those panels to the roof or any available empty space. And for that, it is necessary to check the infrastructure availability and suitability of city. So, this criterion is added to the HDM model to see what experts think about it.

Under 'infrastructure', three sub-criteria are evaluated as below.

a) Grid availability: The electricity is transmitted through interconnected transmission lines. Some lines are transmission lines to transmit the electric energy from one point to another. And some lines are mainly use to distribute that energy over different customers. Both transmission and distribution lines form 'Electric grid'. As shown in the fig.1 above, to install solar panels and use them as a source of energy, electric grid is required. For some solar systems, like solar cells might not need electric grid. But mainly for industrial usage, solar system needs electric grid. And to know how important it is to have electric grid available, this sub-criterion is added.

b) Type of construction suitable for installation: In solar panel installation, sometimes the panels are installed above the roof, sometimes in open space/land. Though the general construction is similar throughout the country, some state policies make some differences in the type of buildings a city has. So, while installing solar panels, it is better to check if the general construction type of buildings in city is suitable or not. That is why this sub-criterion is added.

c) Land availability: Solar panel installation requires space. For large industry, with high energy demand, number of solar panels required might be large. In that case, the panels need be installed in suitable open space. That is why land availability is also one of the factors taken into consideration before selecting the city.

C) Economic:

As the decision model is mainly for business, economy is also an important factor. There is financial investment necessary for any business. And of course, high profit/benefit is expected from the business. At the same time, it is necessary to check if the potential target market gets benefited with the product or not. For example, any industry/company will get attracted to solar panel installation, if they are getting some financial benefits. And that is why the solar panel company must consider the fact about how the client will get benefited from using their product. This fact will be useful in making marketing plans. Below sub-criteria are evaluated under 'economic' criteria.

a) Tax benefits: There is some advantage of tax deduction benefits for any industry which invests in solar energy for their use. Ultimately, if any industry is planning to install solar panels, it might get some tax benefits [13].
b) Government subsidy: Similarly, sometimes government even gives subsidy for solar projects in terms of funding.

Though, there are some policies on central (nationwide) level, which are same to all the cities in India, some policies change as per the state. That is why it is important to decide how those two are important relative to each other.

D) Social:

This is the criteria which is little difficult to measure because it is related to behavioral or emotional factors of people. But at the same time, it is very important because ultimately 'what customer thinks/feels' is going to be the major factor in any business. Below are sub-criteria for 'Social' aspect.

a) Power shortage: This is one of the major problems which Indian citizens face. There are some parts in India, where the electricity is purposely interrupted in specific hours of the day to save energy. (called 'load shading'). This 'power shortage' affects the people's lives, their thinking. Though, this factor can go under economic, the social affects with 'power shortage' can be a major factor which could be make people think about other options of energy sources.
b) People's attitude towards green initiative: Recently, many 'green initiatives' have started by government, industries, companies and even by some small residential society groups. 'Solar panel installation' is also the 'green initiative', because it

promotes the use of solar energy. So, this factor is considered while selecting the market. If common people are prone towards such environmental friendly projects, automatically companies/industries get more confidence in developing or being a part of such projects.

The above criteria and sub-criteria form level 2 and level 3 of the HDM. Level 4 consists of different alternatives. For this HDM models, the alternatives are cities, where the company is planning to target the market. India is a big country. According to the census report of 2011, there are around 7, 935 cities in India [14]. There are some metropolitan cities with more population density, industries etc. For selling solar panels to industries, it would be better to go with metro city at the start. That is why three metro cities located in various parts of India, such as Mumbai, Delhi and Bangalore, are selected as alternatives for this HDM model.

Mumbai: Mumbai has been one of the fastest growing cities in India. It is the capital city of state 'Maharashtra'. It is the most internationalized economy [14]. It is the center for many government offices, major corporate headquarters location, a center for institutional decision-making [15]. Additionally, there are many more small, medium, large business dispersed across Mumbai area. This aspect of 'Mumbai' makes it the attractive city to start new business, because of infrastructure. Therefore, Mumbai is considered an alternative for this model.

Delhi: Delhi is the capital of India. Being the capital, there are number of business, industries in the city. The statistical report from Indian government, shows the number of new companies are increasing year by year [16]. The report also gives the indication of increasing electricity usage. The city currently produces some electricity and buys some electricity from

other states [16]. The city could be a good option in terms of starting a business for solar panels for industries.

Bangalore: Bangalore is the capital city of state 'Karnataka'. Bangalore district is industrially the most advanced district in Karnataka [17]. There are many small scale, medium scale and large scale electronic unit manufacturing companies. The international tech park is a high-tech park built to provide one-stop solutions to multinationals and other conglomeration for conducting high tech business in India [18]. So Bangalore can be an attractive choice for the model of this paper.

These three cities make the fourth and last level of the HDM model.

In short, below are the all the data used for building the HDM model.

Level 1	**Objective**	Selecting Best city for installation of solar panels for industrial usage
Level 2	Criteria	Weather, Infrastructure, Economic, Social
Level 3	Sub-criteria	(Availability of sun light, Bad weather period), (Grid availability, Type of construction suitable for installation, land availability), (Tax benefits, Government subsidy), (Power shortage, People's attitude towards green initiative)
Level 4	Alternatives	Mumbai, Delhi, Bangalore

Table 1. All the levels of HDM

Data sources:

Two main sources of data have been used to collect and evaluate data.

A) Literature research:

To build all the four levels of the model, literature research is done. Many research papers have been written for solar energy usages, renewable sources of energy, scope of solar energy projects in India. Those papers have been used to form the robust HDM model. Additionally,

many government websites, statistical reports, city reports are investigated to check the latest available data.

B) Experts:

For HDM, experts play a very crucial role. Experts' judgements play a significant role for decision making process. For this paper Five experts are selected and approached for their valuable inputs.

Expert 1: The expert has been living in India since around 30 years. Being a Management student with entrepreneurial approach, the expert is well updated with current market situation in market. Economic, political factors, how they affect any business, particularly in India are well known to her. The expert is well aware about general people's attitude and situation in different cities or states in India. So, the expert is chosen to get the insights for all levels of HDM model.

Expert 2: The expert is a civil engineer with high interest in environmental science. The expert is currently working in construction business. At the same time, some solar installation projects are monitored and completed under the expert's supervision. Being a successful entrepreneur, the expert is skilled in making choices and judgements. Also, all the cities are explored by him so it is possible to get the comparison from him. That is why he is chosen as one of the experts to quantify the HDM model.

Expert 3: This expert is working as a project manager in the small scale solar panel installation company. After working in a big technology company for significant number of years, the passion towards business and renewable energy made him take a next step in the career. He joined a start-up company, which is in solar panel business. Currently, he is working on many projects across India. Someone, who is currently working in the same field and has some significant

experience could be the best person to get inputs from. Because he knows what exactly going on in the market. That is why, this expert is chosen as a part of this HDM model expert group.

Expert 4: This expert 4 is a professional working in semiconductor manufacturing company. He has a strong academic background. He is a PhD in chemical engineering. He is an expert in sources of energy. Also, as he has worked on number of research papers, thesis, projects, he is expert in evaluating and analyzing different criteria in any decision-making problem. Also, Being Indian, he knows all the cities thoroughly. Additionally, he is interested in starting his own solar business in India. And he has been already studying the market situations in India. So, this expert is chosen for this HDM model expert group.

Expert 5: The expert is highly educated professional. He is currently working in multinational company. He has lived in all the three cities for some years. That is why he is aware of the current conditions in cities. Someone, who knows how exactly the situation is in cities, could give some valuable real insights. He can even relate all the cities with the real situation. That is why the expert is chosen for this HDM model.

ANALYSIS AND KEY FINDINGS

HDM results:

After getting all the required inputs from all experts, HDM has calculated the final weighted values for all three alternatives. Below are the results for all three cities, considering the opinions from all experts.

Expert	Mumbai	Bangalore	Delhi	Inconsistency
Expert 1	0.18	0.37	0.45	0
Expert 2	0.28	0.22	0.5	0
Expert 3	0.34	0.33	0.33	0
Expert 4	0.29	0.42	0.29	0.04
Expert 5	0.39	0.28	0.32	0
Mean	**0.3**	**0.32**	**0.38**	
Minimum	0.18	0.22	0.29	
Maximum	0.39	0.42	0.5	
Std. Deviation	0.07	0.07	0.08	
Disagreement				0.072

Table 2. Final results from HDM

Form this, 'Delhi' is the city with high ranking.

Below table shows the mean values of weightages for criteria, given by all experts.

Expert	Weather	Infrastructure	Economic	Social
Expert 1	0.34	0.06	0.56	0.04
Expert 2	0.5	0.17	0.17	0.17
Expert 3	0.18	0.3	0.3	0.22
Expert 4	0.27	0.12	0.58	0.03
Expert 5	0.12	0.33	0.32	0.24
Mean	0.282	0.196	0.386	0.14

Table 3. Results for weightages for criteria

The same results are converted into pie chart.

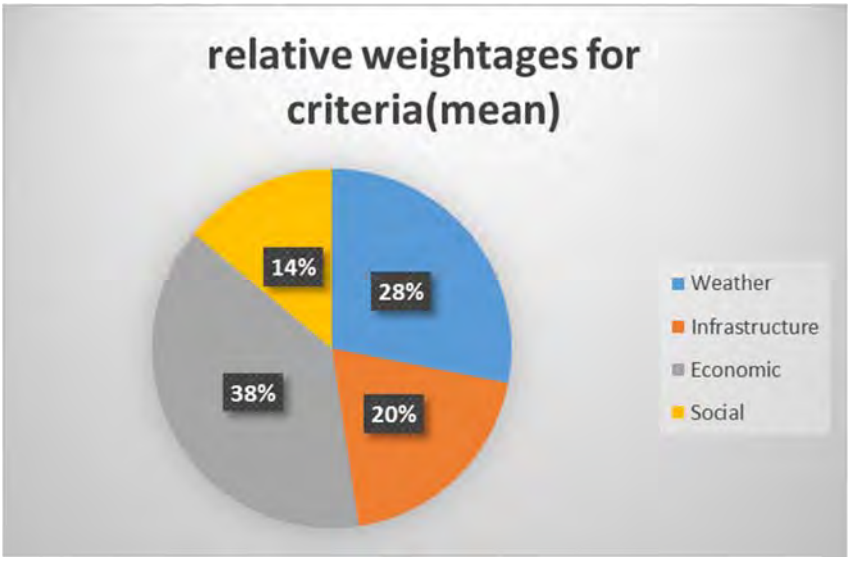

Fig 5. Graph with relative weightages to criteria

From the above table, 'economic' is the highest-ranking category followed by weather. Infrastructure and social play later roles and both get approximately similar weightages.

Third table shows the mean values of sub-criteria details.

Sub-criteria	Weather	Infrastructure	Economic	Social
Availability of sun-light	0.864	0	0	0
Bad weather period	0.136	0	0	0
Grid availability	0	0.426	0	0
Type of construction	0	0.262	0	0
Land availability	0	0.308	0	0
Tax benefits	0	0	0.522	0
Government subsidy	0	0	0.478	0
power shortage	0	0	0	0.708
people's attitude towards green initiatives	0	0	0	0.292

Table 4. sub-criteria main values

The above values give, which sub-criteria got more ranking relative to others.

The results are shown in the form of graph below.

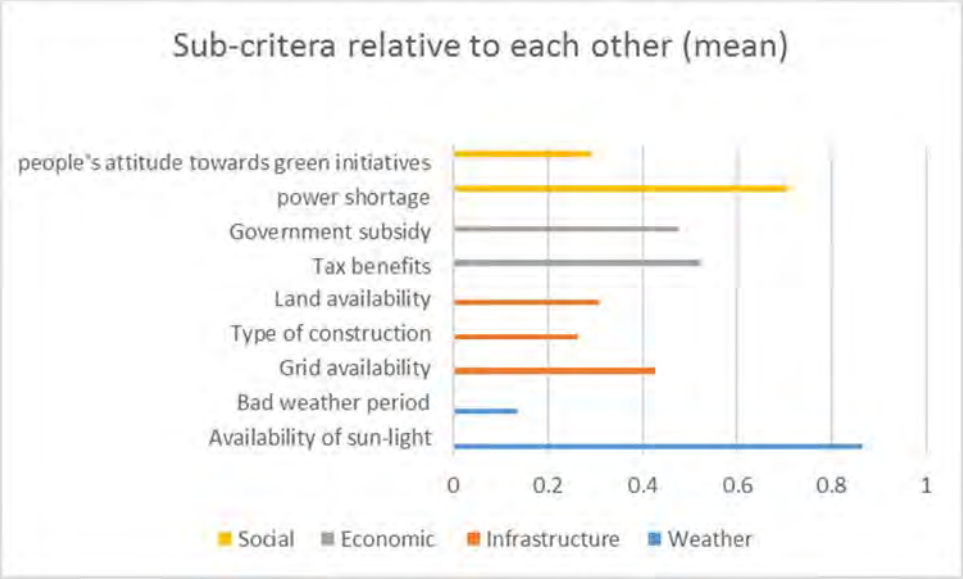

Fig 6. Graph for sub-criteria weightages.

Under 'weather', 'availability of sun-light' is way high that bad weather.

Similarly, under 'Infrastructure', 'grid availability' is more important.

For 'Economic', both tax benefits and subsidy are around the same level.

And for 'social', 'power shortage' gains significant weightage than people' attitude.

Finally, the below table shows the mean values of weightages for all sub-criteria for each city relative to each other.

City	Availability of sun-light	Bad weather period	Grid availability	Type of construction	Land availability	Tax benefits	Government subsidy	power shortage	people's attitude towards green initiatives
Mumbai	0.322	0.284	0.456	0.324	0.264	0.28	0.22	0.264	0.318
Bangalore	0.426	0.462	0.254	0.312	0.304	0.304	0.232	0.274	0.348
Delhi	0.252	0.254	0.288	0.362	0.432	0.412	0.548	0.464	0.334

Table 5. Sub-criteria weightages

The above values are represented in graphical format as below.

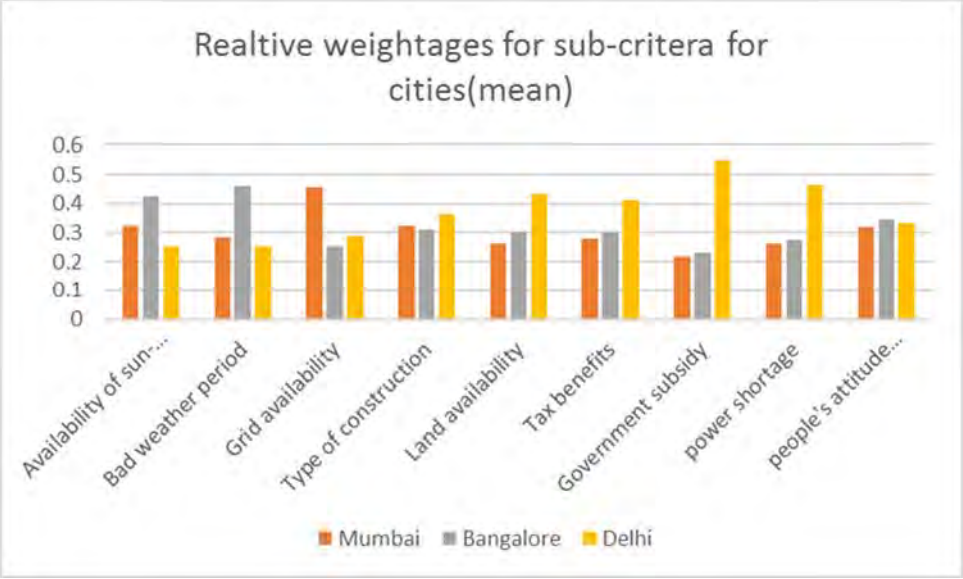

Fig 7. Sub-weightages for all cities relative values (mean)

For each sub-criterion, different city got the highest ranking.

Inconsistency:

The inconsistency value gives a measurement about the expert's consistency in giving judgment. It basically checks if the 'transitivity' law is followed or not. When there is zero inconsistency in expert's weightages, there is a good chance that the expert is skilled in that area, or at least his views are uniform or robust throughout. If there is some inconsistency in expert's judgement, it is still acceptable if that falls under the range of 0% to 10% [9]. Many times, the inconsistency can be a cause of human error. So, in case of significant inconsistency, the second iteration of expert's judgments can be taken.

For this paper, four experts have zero inconsistency in their judgements. One expert has 4% of inconsistency, which is still in acceptable range. In the pairwise comparison, the expert was little more inconsistent for criteria level [Appendix B, expert 4]. That major inconsistency was carry forward in further levels. But as the final results are acceptable, the expert's judgements are still considered as valid.

Disagreement:

The disagreement value gives a measurement as to how much level the experts are disagree with each other. Experts come from diverse background, diverse cultures, diverse education etc. That makes every expert think in different ways. That is why there is a chance that each expert has his/her own final decision. So, the disagreement to some extent is acceptable. The threshold value for the acceptance is 10% [9].

For this paper, there is disagreement, but the value is 0.072 (7.2%), which is in range. So, it can be said that mostly expert were in agreement with each other in tolerable range.

Result analysis for each level:

Level 1:

Most of the experts have ranked 'economic' criteria as the number one. This clearly makes sense, because the decision is made for the company. And for new business, money is the most important thing. Same applies with the customers. Additionally, the customers for this business is 'industries'. And those industries will also get attracted towards solar panels, if they find the financial advantage. Any advantage in terms of money, tax or subsidy will make them think of solar panel installation project. That is why 'economic' criteria wins.

Level 2:

For sub-criteria, 'availability of sunlight' is way important than 'bad weather'. In India, there is a possibility of heavy rain in some parts. But that rain will not be as bad to damage or negatively impact solar panels. So, the bad weather plays less role in decision making. The sub-criteria under 'economic' and 'infrastructure' do not differ in large amount. They vary from each other by around 0.1 to 0.2. Under 'social', again 'power shortage' is way more than 'people's attitude'. In India, as supply is less than demand, in case of energy, there is always power cuts. These power cuts affect 'people's day to day activities'. And that makes them think about other sources of energy. That is why the factor gets more importance.

Level 3

For all the cities, many of the factors get similar weightages with 0.1 or 0.25 of the difference. The main sub-criteria those make the differentiation are 'tax benefits' and 'government subsidy' and 'power shortage'. For all these 'Delhi' is on the top. Being the capitol

of India, Delhi is the center of country from where the country defines the policies, laws, missions, vision. That is why it is easier to get all the 'economic' benefits in 'Delhi' than other cities.

Level 4

So, overall, when looking at the results by all experts, it seems that they have thought thoroughly about all the criteria and sub-criteria. All the weightages and differences in weightages are realistic based on the current situation in cities and in country.

With all that 'Delhi' is the city where the business needs to be start.

Sensitivity analysis

To check the 'sensitivity' of the model in one way, 'what if' analysis way is followed. Currently there are five experts. But what if expert 1 is removed from the whole model?' And when he/she is removed, will the results be same or there is difference in rankings or average? This approach is used to check how the results vary with removal of different experts. Below graph shows the results from such analysis.

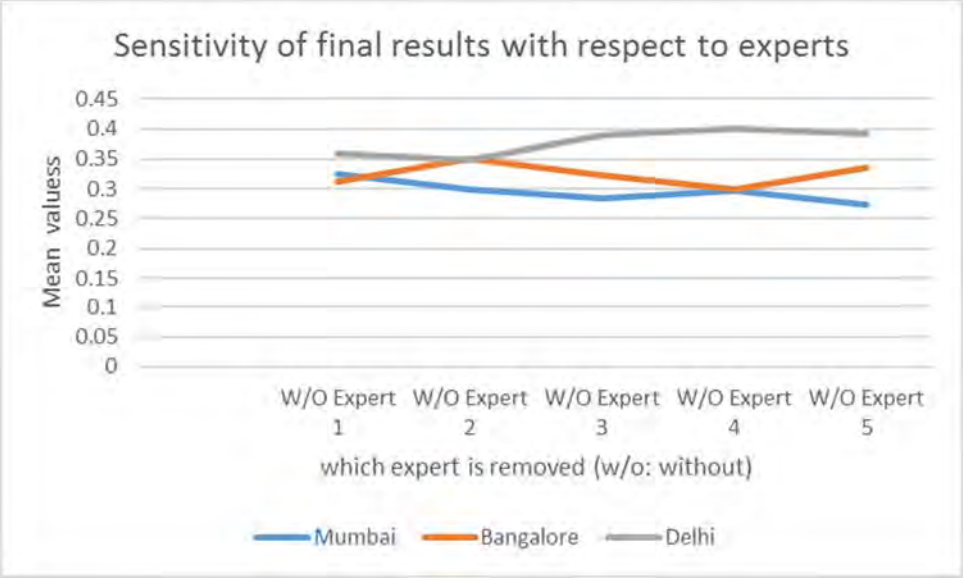

Fig 8. Sensitivity graph

In this case, 'Delhi' maintain the top rank in 4 cases. Only when expert 2 is removed, 'Bangalore' is at the top. But that difference is very low, which is around 0.01. So clearly. 'Delhi' is the final choice.

The minimal value of disagreement could be justified by this graph. As, most of the experts are on quite same page, the value is less and the sensitivity graph gives almost consistent results.

So, the final decision of this model is 'Delhi is the place to start the solar panel installation business for industrial usage'.

FUTURE RESEARCH

Being such a vast topic, it might be wrong to say the model is perfect. There are some ways with which the model could be refined depending on the specific details of the decision maker. Below are some improvements or future research suggested for the study.

1) Though, the paper gives a basic model for decision making and tries to consider most important factors (in terms of criteria, sub-criteria) affecting decision, the same model can be expanded with more factors. For example, in the criteria of 'weather', this paper has 'bad weather' as one of the sub-criteria. It could be expanded further as 'bad wind', 'bad rain' etc. This way, the model could be refined to next level.
2) For the scope of this paper, only three cities are considered as alternatives. But the model can be expanded with more cities. If the decision maker has a limitation of running the

business only in one state, the model can be used to compare different towns in one state. But in that case, the towns must be comparable to each other.

3) Some experts from government could be added in expert group to get some more inputs for the decision model. Particularly, it would be interesting to know how government is trying to implement green initiatives (like solar projects) to boost the use of renewable sources of energy. Mainly, political and economic factors could be better evaluated by the expert working directly with the department of energy in India.
4) The current model is built mainly for industrial use. But it can be converted to see which city is best for solar panel installation in residential area. Only small criteria can be changed and the model could be used for decision making.

Above future research suggests the model can be expanded as needed but with some small changes in it.

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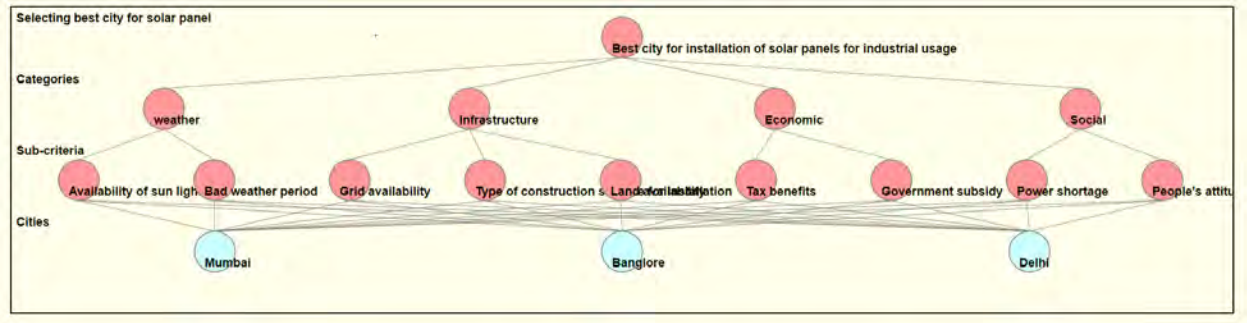
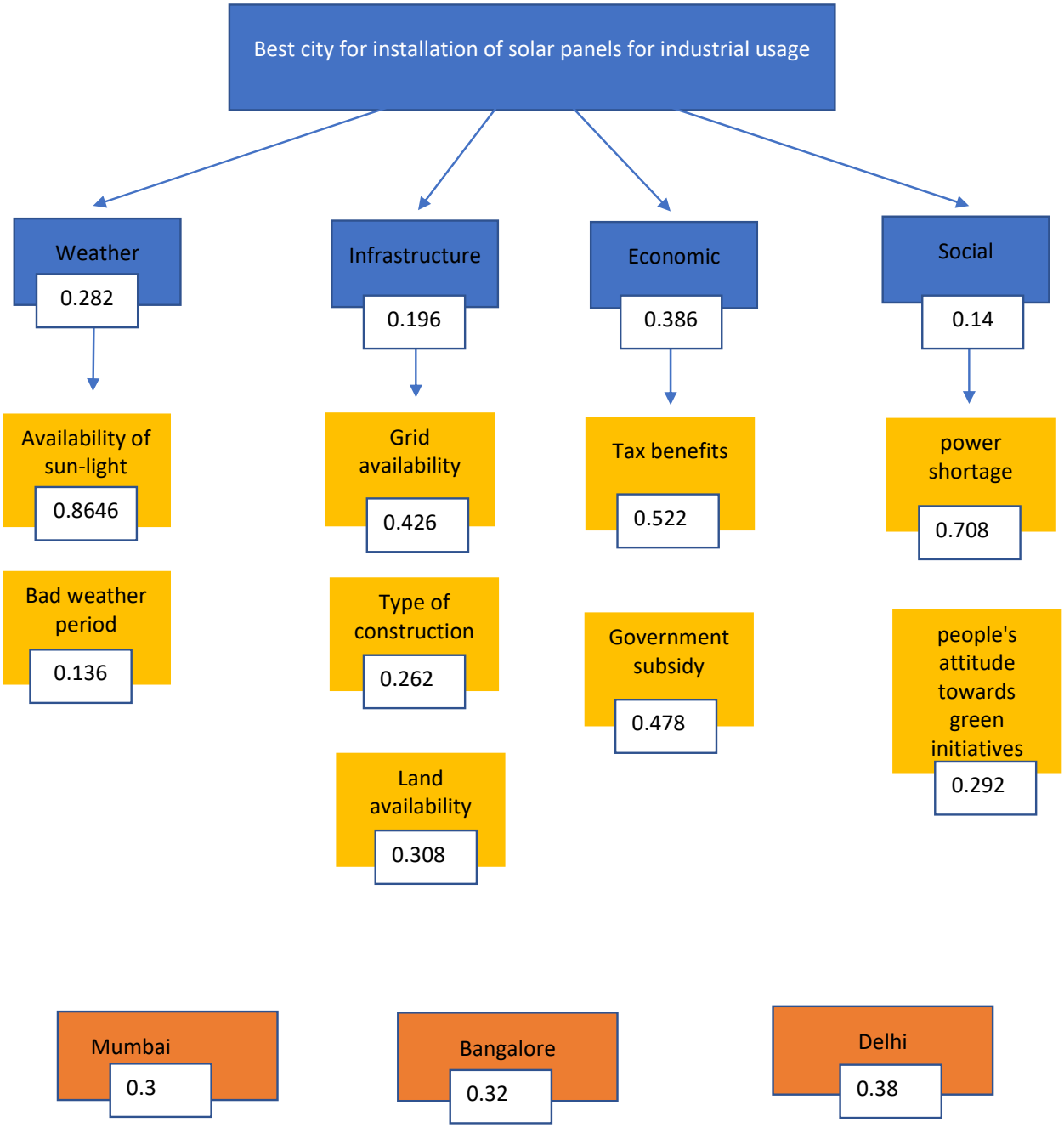
APPENDIX A – FINAL, QUANTIFIED MODEL

Below is the HDM model from HDM tool:



Below figure shows the HDM model with weighted average values for all levels.



Note: The sub-categories are in yellow boxes and the boxes below the criteria are sub-criteria for that criteria. All the vertical sub-criteria come under same criteria.

APPENDIX B – AHP/HDM PCM DATA TABLES

Below are the details of pairwise comparison for all the experts from HDM for all the levels.

Also, inconsistency is present in the tables for individual expert.

Expert 1)

Level-1	Best city for installation of solar panels for industrial usage
weather	0.34
Infrastructure	0.06
Economic	0.56
Social	0.04
Inconsistency	0.02

Level-2	weather	Infrastructure	Economic	Social
Availability of sun light	0.93	0.00	0.00	0.00
Bad weather period	0.07	0.00	0.00	0.00
Grid availability	0.00	0.62	0.00	0.00
Type of construction suitable for installation	0.00	0.11	0.00	0.00
Land availability	0.00	0.27	0.00	0.00
Tax benefits	0.00	0.00	0.75	0.00
Government subsidy	0.00	0.00	0.25	0.00
Power shortage	0.00	0.00	0.00	0.74
People's attitude towards green initiative	0.00	0.00	0.00	0.26
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Availability of sun light	Bad weather period	Grid availability	Type of construction suitable for installation	Land availability	Tax benefits	Government subsidy	Power shortage	People's attitude towards green initiative
Mumbai	0.22	0.33	0.41	0.23	0.28	0.13	0.11	0.27	0.34
Banglore	0.69	0.33	0.30	0.43	0.33	0.19	0.17	0.36	0.43
Delhi	0.09	0.33	0.28	0.34	0.39	0.68	0.71	0.36	0.24
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The final result:

Level-1	Best city for installation of solar panels for industrial usage
Mumbai	0.18
Banglore	0.37
Delhi	0.45
Inconsistency	0.00

Expert 2)

Level-1	Best city for installation of solar panels for industrial usage
weather	0.50
Infrastructure	0.17
Economic	0.17
Social	0.17
Inconsistency	0.00

Level-2	weather	Infrastructure	Economic	Social
Availability of sun light	0.80	0.00	0.00	0.00
Bad weather period	0.20	0.00	0.00	0.00
Grid availability	0.00	0.14	0.00	0.00
Type of construction suitable for installation	0.00	0.43	0.00	0.00
Land availability	0.00	0.43	0.00	0.00
Tax benefits	0.00	0.00	0.40	0.00
Government subsidy	0.00	0.00	0.60	0.00
Power shortage	0.00	0.00	0.00	0.70
People's attitude towards green initiative	0.00	0.00	0.00	0.30
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Availability of sun light	Bad weather period	Grid availability	Type of construction suitable for installation	Land availability	Tax benefits	Government subsidy	Power shortage	People's attitude towards green initiative
Mumbai	0.27	0.25	0.36	0.38	0.29	0.23	0.27	0.26	0.33
Banglore	0.12	0.60	0.12	0.16	0.20	0.48	0.16	0.26	0.19
Delhi	0.61	0.16	0.52	0.47	0.51	0.29	0.57	0.48	0.47
Inconsistency	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The final result:

Level-1	Best city for installation of solar panels for industrial usage
Mumbai	0.28
Banglore	0.22
Delhi	0.50
Inconsistency	0.00

Expert 3)

Level-1	Best city for installation of solar panels for industrial usage
weather	0.18
Infrastructure	0.30
Economic	0.30
Social	0.22
Inconsistency	0.00

Level-2	weather	Infrastructure	Economic	Social
Availability of sun light	0.85	0.00	0.00	0.00
Bad weather period	0.15	0.00	0.00	0.00
Grid availability	0.00	0.47	0.00	0.00
Type of construction suitable for installation	0.00	0.19	0.00	0.00
Land availability	0.00	0.33	0.00	0.00
Tax benefits	0.00	0.00	0.30	0.00
Government subsidy	0.00	0.00	0.70	0.00
Power shortage	0.00	0.00	0.00	0.81
People's attitude towards green initiative	0.00	0.00	0.00	0.19
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Availability of sun light	Bad weather period	Grid availability	Type of construction suitable for installation	Land availability	Tax benefits	Government subsidy	Power shortage	People's attitude towards green initiative
Mumbai	0.48	0.45	0.33	0.33	0.21	0.26	0.29	0.43	0.19
Banglore	0.31	0.23	0.33	0.33	0.48	0.28	0.29	0.29	0.51
Delhi	0.21	0.32	0.33	0.33	0.31	0.45	0.43	0.29	0.31
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The final result:

Level-1	Best city for installation of solar panels for industrial usage
Mumbai	0.34
Banglore	0.33
Delhi	0.33
Inconsistency	0.00

Expert 4)

Level-1	Best city for installation of solar panels for industrial usage
weather	0.27
Infrastructure	0.12
Economic	0.58
Social	0.03
Inconsistency	0.20

Level-2	weather	Infrastructure	Economic	Social
Availability of sun light	0.99	0.00	0.00	0.00
Bad weather period	0.01	0.00	0.00	0.00
Grid availability	0.00	0.77	0.00	0.00
Type of construction suitable for installation	0.00	0.18	0.00	0.00
Land availability	0.00	0.04	0.00	0.00
Tax benefits	0.00	0.00	0.80	0.00
Government subsidy	0.00	0.00	0.20	0.00
Power shortage	0.00	0.00	0.00	0.99
People's attitude towards green initiative	0.00	0.00	0.00	0.01
Inconsistency	0.00	0.07	0.00	0.00

Level-3	Availability of sun light	Bad weather period	Grid availability	Type of construction suitable for installation	Land availability	Tax benefits	Government subsidy	Power shortage	People's attitude towards green initiative
Mumbai	0.20	0.19	0.79	0.33	0.11	0.33	0.04	0.04	0.33
Banglore	0.75	0.77	0.21	0.33	0.26	0.33	0.25	0.12	0.33
Delhi	0.05	0.04	0.00	0.33	0.63	0.33	0.71	0.85	0.33
Inconsistency	0.09	0.09	0.09	0.00	0.00	0.00	0.06	0.03	0.00

The final result:

Level-1	Best city for installation of solar panels for industrial usage
Mumbai	0.29
Banglore	0.42
Delhi	0.29
Inconsistency	0.04

Expert 5)

Level-1	Best city for installation of solar panels for industrial usage
weather	0.12
Infrastructure	0.33
Economic	0.32
Social	0.24
Inconsistency	0.00

Level-2	weather	Infrastructure	Economic	Social
Availability of sun light	0.75	0.00	0.00	0.00
Bad weather period	0.25	0.00	0.00	0.00
Grid availability	0.00	0.13	0.00	0.00
Type of construction suitable for installation	0.00	0.40	0.00	0.00
Land availability	0.00	0.47	0.00	0.00
Tax benefits	0.00	0.00	0.36	0.00
Government subsidy	0.00	0.00	0.64	0.00
Power shortage	0.00	0.00	0.00	0.30
People's attitude towards green initiative	0.00	0.00	0.00	0.70
Inconsistency	0.00	0.00	0.00	0.00

Level-3	Availability of sun light	Bad weather period	Grid availability	Type of construction suitable for installation	Land availability	Tax benefits	Government subsidy	Power shortage	People's attitude towards green initiative
Mumbai	0.44	0.20	0.39	0.35	0.43	0.45	0.39	0.32	0.40
Banglore	0.26	0.38	0.31	0.31	0.25	0.24	0.29	0.34	0.28
Delhi	0.30	0.42	0.31	0.34	0.32	0.31	0.32	0.34	0.32
Inconsistency	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The final result:

Level-1	Best city for installation of solar panels for industrial usage
Mumbai	0.39
Banglore	0.28
Delhi	0.32
Inconsistency	0.00

The below table shows the inconsistency and disagreement for all experts.

Best city for installation of solar panels for industrial usage	Mumbai	Banglore	Delhi	Inconsistency
Expert 2	0.28	0.22	0.5	0
Expert 1	0.18	0.37	0.45	0
Expert 5	0.39	0.28	0.32	0
Expert 4	0.29	0.42	0.29	0.04
Expert 3	0.34	0.33	0.33	0
Mean	0.3	0.32	0.38	
Minimum	0.18	0.22	0.29	
Maximum	0.39	0.42	0.5	
Std. Deviation	0.07	0.07	0.08	
Disagreement				0.072

Here, the names are replaced by the expert numbers for the confidentiality terms.

Below is F-test report from HDM

The statistical F-test for evaluating the null hypothesis (Ho: ric = 0) is obtained by dividing between-subjects variability with residual variability:

Source of Variation	Sum of Square	Deg. of freedom	Mean Square	F-test value
Between Subjects:	0.02	2	.009	.85
Between Conditions:	0.00	4	0.000	
Residual:	0.08	8	0.010	
Total:	**0.10**	**14**		
Critical F-value with degrees of freedom 2 & 8 at 0.01 level:				**8.65**
Critical F-value with degrees of freedom 2 & 8 at 0.025 level:				**6.06**
Critical F-value with degrees of freedom 2 & 8 at 0.05 level:				**4.46**
Critical F-value with degrees of freedom 2 & 8 at 0.1 level:				**3.11**