



suggesting broad areas of possible impacts. Westman (1985) studied Checklist method. The author reported that, this method is too general or incomplete. It does not illustrate interactions between effects. The number of categories to be reviewed can be immense, thus distracting from the most significant impacts and the identification of effects to be qualitative and subjective. MoEF (1991) advised Delphy method for assessment of significance of impact by network matrix and Hazardous waste site selection by integration technique. Sinha S. (1998) studied EIA methods. The author reported that, a number of methodologies have been developed for assessment of environmental impacts and most of the methods suffer from excessive dependence on subjective judgments and are weak in predicting and quantifying the impact of the project on the environment but the development of computer-aided EIA have been identified as most effective approach. Ponce V. (2008) studied Battelle method. OBJECTIVE OF STUDY: To overcome limitations of Ad hoc, Checklist, Matrix, Mathematical matrices and Network method there is need to study use of Battelle method for assessment of environmental impact. The main objectives of this study is to develop a computer program on Battelle method to provide flexibility to expert judgments in entering of input data, maximize accuracy in result, provide baseline data for new project and minimize time, manpower, complicated work for large project. This proposed study will be applicable to predict the impact, development of feasibility study of project, avoiding environmental disturbances by taking appropriate measures, avoid excessive financial burden for involving the environmental

issue after implementation of project. PROPOSED WORK: As discussed in literature review Battelle methods are more helpful in EIA aspect (Ponce, 2008; Sinha, 1998; MoEF, 1991). In this study, a case study on Shri Mahakali sugar industry at Rajarambapunagar, Kavathe Mahankal is selected for analysis of EIA by Battelle. The objectives of proposed work are as follows: Analysis of EIA by Battelle method. To study various attributes with impact potential of proposed study area of sugar industry in relation with Battelle method To study EIA of sugar industry by Battelle method Analysis and development of computer program for EIA by Battelle method. The Battelle methods form basis of this study. Hence these methods are discussed in the Chapter

## 2. Material and Methods

The Battelle Method: The Battelle method (DEE *et al.*, 1973) has been identified as one of the most quantitative method. It can be easily used in different projects. The principle lies in splitting the environmental impact in four major categories: Ecology, Environmental contamination, Aesthetics and Human interest. These categories are divided in to thematic data as shown below. The environmental classification as suggested by Battelle method in view of above four categories and their corresponding relative weights are shown in Table 2.1. These thematic data are divided into environmental indicators. For example in the sugar industry, water pollution could be represented by: BOD, pH, SS, COD, Oil and Grease, TDS etc.

**Table 1:** The Battelle environmental classification and their corresponding relative weights

<b>ECOLOGY</b>	<b>240</b>	<b>ENVIRONMENTAL POLLUTION</b>	<b>402</b>
<b>Terrestrial Species and Populations</b>		<b>Water Quality</b>	
Browsers and grazers	14	Basin hydrologic loss	20
Crops	14	Biochemical oxygen demand	25
Natural vegetation	14	Dissolved oxygen	31
Past species	14	Fecal coliforms	18
Upland game birds	14	Inorganic carbon	22
<b>Aquatic Species and Populations</b>		Inorganic nitrogen	25
Commercial fisheries	14	Inorganic phosphate	28
Natural vegetation	14	Pesticides	16
Pest species	14	pH	18
Sport fish	14	Stream flow variation	28
Water fowl	14	Temperature	28
<b>Terrestrial Habitats and Communities</b>		Total dissolved solids	25
Food web index	12	Toxic substances	14
Land use	12	Turbidity	20
Rare and endangered species	12	<b>Air Quality</b>	
Species diversity	14	Carbon monoxide	5
<b>Aquatic Habitats and Communities</b>		Hydrocarbons	5
Food web index	12	Nitrogen oxides	10
Land use	12	Particulate matter	12
Rare and endangered species	12	Photochemical oxidants	5
Species diversity	14	Sulphur oxides	10
<b>AESTHETICS</b>	<b>153</b>	<b>HUMAN INTEREST/SOCIAL</b>	<b>205</b>
<b>Land</b>		<b>Education/Scientific</b>	
Geologic surface material	6	Archeological	13
Relief and topographic character	16	Ecological	13
Width and alignment	10	Geological	11
<b>Air</b>		Hydrological	11
Odour and visual	3	<b>Historical</b>	
Sounds	2	Architecture and styles	11
<b>Water</b>		Events	11
Appearance of water	10	Persons	11

Land and water interface	16
Odour and floating material	6
Water surface area	10
Wooded and geologic shoreline	10
<b>Biota</b>	
Animals -domestic	5
Animals -wild	5
Diversity of vegetation types	9
Variety within vegetation types	5
<b>Man-Made Objects</b>	
Man made objects	10
<b>Composition</b>	
Composite effect	15
Unique composition	15

Religions and cultures	11
'Western Frontiers'	11
<b>Cultures</b>	
Indians	14
Other ethnic groups	7
Religious groups	7
<b>Mood/ Atmosphere</b>	
Awe/inspiration	11
Isolation/solitude	11
Mystery	4
'Oneness' with nature	11
<b>Life Patterns</b>	
Employment opportunities	13
Housing	13
Social interactions	11

Once the environmental indicators are chosen, the method follows three steps:

First step: at this stage, the goal of the method is to transform environmental indicators into environmental quality. The notation table defines a number from 0 to 1 (0 for poor quality and 1 for good quality). Thus it is possible to quantify evaluation both in the wrong or right direction (environmental deterioration or improvement).

Second step: a total of a 1000 points (or Parameter Importance Unit: PIU) are shared among the indicators by the user or expert of the EIA. They reflect the relative importance of each parameter.

Third step: the comparison between the situation with and without the project is done in Environmental Impact Units (EIU). It can even reflect benefits or losses in terms of environmental conditions.

Mathematically, it is represented as follows:

$$\sum_{i=1}^m EIU = \sum (EQ_i)_1 \cdot PIU_i - \sum (EQ_i)_2 \cdot PIU_i$$

Where:

EIU = Environmental impact unit.

(EQ<sub>i</sub>)<sub>1</sub> = Environmental quality for indicator "i" with the project conditions. (lies between 0 to 1).

(EQ<sub>i</sub>)<sub>2</sub> = Environmental quality for indicator "i" without the project condition. (lies between 0 to 1).

PIU<sub>i</sub> = Parameter Importance Unit/Relative weight of the indicator "i".

m = Total numbers of environmental indicators.

### 3. Result and Discussion

The case study of Shri Mahakali sugar industry at Rajarambapunagar, Kavathe Mahankal was selected for analysis of EIA methodology. The data collected for analysis of EIA methodology is given in following section.

s:The degree of environmental impact obtained for Shri Mahankali sugar industry corresponds to the total value of 70.7 Units. This is given in Table 3.9.

Table 3.9: Environmental impact due to Shri Mahankali sugar industry

The environmental categoriwise results of environmental impact due to Shri Mahankali sugar industry (Sangli-Maharashtra) are given in Table 3

Table 2: Environmental categoriwise results of environmental impact due to Shri Mahankali sugar industry

Sr. No.	Environmental categories	PIU	EIU	EIU in
1	Ecology	148	41.4	27.97
2	Environmental contamination	510	-93.4	-18.3
3	Aesthetics	153	45.7	29.87
4	Human interest or social	189	77	40.74
Total		1000	70.7	7.07

The EIA of sugar industry is studied by Battelle and Delphy method. The relative advantages, disadvantages and future work requirements in these methods are discussed below

#### The Battelle Method

##### Advantages

1. The Battelle method can be easily used for the case study considered in this scope of study.
2. The principal advantage of this method is that it gives a comparative analysis between several situations. Thus, it is particularly efficient when effecting choice between alternatives.
3. This method has been identified as one of the most quantitative method.
4. This is the easiest method as compared to other methods for EIA.
5. It gives flexibility for required changes in the environmental indicators and it's PIU values according to type of the project.
6. It gives flexibility for required changes in the EQ value of environmental indicators.
7. The flexibility for required changes of indicators and it's PIU values according to project results in better EIA.
8. The mathematical calculations are based on only one type of mathematical expression for determination of EIU.
9. There is less theoretical part.

##### Disadvantages

1. The environmental acceptibility range of EIU is not defined.

2. In this method mathematical calculation part is maximum and critical. Therefore any changes in input data leads to complications.
3. In this method resources requirement is high such as time and skilled manpower.
4. The result of EIA depends on expert's judgment.
5. The environmental categoriwise results are not defined.
6. In this method judgment of inputs such as environmental indicators, PIU and EQ are not defined.
7. There is difficult to choose environmental indicator.
8. There is difficult to share PIU of environmental indicators.
9. There is difficult to decide environmental conditions with or without project.
10. There is difficult to transfer of environmental indicator into environmental quality

#### 4. Conclusion

1. This study gives advantages, disadvantages and suitability of Battelle method for EIA.
2. The development of computer program can be easily applicable in different project. It gives flexibility in entry of input data. This is useful to maximize accuracy, this is also useful to minimize manpower, manmade mistakes, and complicated work for large project.
3. This study is also applicable for prediction of the impact, avoiding environmental disturbances by taking appropriate measures and avoid excessive financial burden for connecting the environmental issue after implementation of project.

#### 5. Future Scope

The above research work further can be extended for solving problems of different kind of project for the betterment of society.

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#### Author Profile

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Table 3

<b>RESULTS:</b>				
<b>NAME OF INDUSTRY :</b>	Shri Mahakali Sugar Industry, Rajaram Bapu Nagar, Kavathe Mahankal. At and Post: Kavathe Mahankal, Taluka: Kavathe Mahankal, Dist: Sangli.			

The sum of Parameter Importance Unit (PIU) of the categories in this tables are **1000** Points

Sr. No.	Environmental Categories	PIU	(EQi) <sub>1</sub>	(EQi) <sub>2</sub>	EIU
	<b>Ecology</b>	<b>148</b>			
<b>1</b>	<b>Terrestrial species and populations</b>				
	Browsers and grazers	9	0.7	0.4	2.7
	Crops	9	0.8	0.5	2.7
	Natural vegetation	9	0.8	0.5	2.7
	Past species	9	0.6	0.3	2.7
	Birds	9	0.8	0.6	1.8
<b>2</b>	<b>Aquatic species and populations</b>				
	Fisheries	9	0.5	0.3	1.8
	Natural vegetation	9	0.8	0.3	4.5
	Past species	9	0.5	0.2	2.7
	Fish	9	0.4	0.2	1.8
	Waterfowl	9	0.6	0.2	3.6
<b>3</b>	<b>Terrestrial habitats and communities</b>				
	Food web index	7	0.8	0.5	2.1
	Land use	7	0.7	0.5	1.4
	Rare and endangered specie	7	0.7	0.4	2.1
	Species diversity	8	0.6	0.5	0.8
<b>4</b>	<b>Aquatic habitats and communities</b>				
	Food web index	7	0.8	0.6	1.4
	Land use	7	0.7	0.4	2.1
	Rare and endangered specie	7	0.7	0.4	2.1
	Species diversity	8	0.6	0.3	2.4
<b>Sub Total EIU</b>					<b>41.4</b>

Sr. No.	Environmental Categories	PIU	(EQi) <sub>1</sub>	(EQi) <sub>2</sub>	EIU
	<b>Environmental contamination</b>	<b>510</b>			
<b>1</b>	<b>Waste water quality</b>				
	Water consumption	56	0.5	1	-28
	Biochemical oxygen demand	48	0.9	1	-4.8
	Suspended solid	48	0.6	1	-19.2
	Chemical oxygen demand	48	0.9	1	-4.8
	Oil and Grease	48	0.9	1	-4.8
	T.D.S.	48	0.9	1	-4.8
	pH	38	0.9	1	-3.8
<b>2</b>	<b>Air quality</b>				
	Nitrogen oxides	24	0.9	1	-2.4
	Sulphur oxidants	24	0.8	1	-4.8
	Suspended particulate matter	28	0.6	1	-11.2
	Other	12	0.9	1	-1.2
<b>3</b>	<b>Land pollution</b>				
	Land use	32	0.9	1	-3.2
	Soil erosion	32	0.8	0.4	12.8
<b>4</b>	<b>Noise pollution</b>				
	Noise from machinery	12	0.4	1	-7.2
	Noise from vehicles	12	0.5	1	-6
<b>Sub Total EIU</b>					<b>-93.4</b>

Sr. No.	Environmental Categories	PIU	(EQi) <sub>1</sub>	(EQi) <sub>2</sub>	EIU
	<b>Aesthetics</b>	<b>153</b>			
<b>1</b>	<b>Land</b>				
	Geologic surface material	6	0.7	0.4	1.8
	Relief and topographic character	16	0.6	0.4	3.2
	Width and alignment	10	0.6	0.3	3
<b>2</b>	<b>Air</b>				
	Odour and visual	3	0.8	1	-0.6
	Sounds	2	0.5	1	-1
<b>3</b>	<b>Water</b>				
	Appearance of water	10	1	1	0
	Land and water interface	16	0.8	0.3	8
	Odour and floating material	6	1	1	0
	Water surface area	10	0.8	0.3	5
	Wooded and geologic shoreline	10	0.6	0.3	3
<b>4</b>	<b>Biota</b>				
	Animals - domestic	5	0.9	0.4	2.5
	Animals - wild	5	0.6	0.4	1
	Diversity of vegetation types	9	0.7	0.5	1.8
	Variety within vegetation types	5	0.7	0.5	1
<b>5</b>	<b>Man-made objects</b>				
	Man-made objects	10	0.8	0.3	5
<b>6</b>	<b>Composition</b>				
	Composite effect	15	0.8	0.4	6
	Unique composition	15	0.8	0.4	6
<b>Sub Total EIU</b>					<b>45.7</b>

Sr. No.	Environmental Categories	PIU	(EQi) <sub>1</sub>	(EQi) <sub>2</sub>	EIU
	<b>Human interest or Social</b>	<b>189</b>			
<b>1</b>	<b>Education or scientific packages</b>				
	Archaeological	8	0.7	0.4	2.4
	Ecological	8	0.8	0.5	2.4
	Geological	5	0.7	0.5	1
	Hydrological	5	0.8	0.4	2
<b>2</b>	<b>Historical packages</b>				
	Events	5	0.6	0.4	1
	Persons	5	0.4	0.3	0.5
	Religions and cultures	5	0.6	0.5	0.5
<b>3</b>	<b>Cultures</b>				
	Indians	8	0.8	0.7	0.8
	Other ethnic groups	5	0.8	0.3	2.5
<b>4</b>	<b>Mood or atmosphere</b>				
	Admiration	5	0.8	0.4	2
	Isolation	5	0.8	0.3	2.5
	Oneness with nature	5	0.8	0.4	2
<b>5</b>	<b>Life patterns</b>				
	Employment opportunities	16	0.9	0.2	11.2
	Housing	16	0.8	0.4	6.4
	Social interactions	14	0.8	0.3	7
<b>6</b>	<b>Composition</b>				
	Economic view	16	0.9	0.3	9.6
	Agricultural view	16	0.8	0.4	6.4
	Public view	14	0.8	0.4	5.6
	Health related plans	14	0.7	0.4	4.2
	Development plans	14	0.8	0.3	7
<b>Sub Total EIU</b>					<b>77</b>

**Total sum of EIU** =  $EIU = \sum_{i=1}^{m_1} (EQi)_1 + PIU_1 + \sum_{i=1}^{m_2} (EQi)_2 + PIU_2 = 70.7$  Points.

**RESULT:** The degree of environmental impact obtain from the study area of sugar industry corresponds to the total value of **70.7** Units.

THE CATEGORIWISE RESULTS ARE AS FOLLOWS:					
SR. NO.	CATEGORIES	PIU	EIU	EIU IN %	COLOUR CODE
1	Ecology	148	41.4	27.97	27.97
2	Environmental contamination	510	-93.4	-18.3	-18.3
3	Aesthetics	153	45.7	29.87	29.87
4	Human interest or Social	189	77	40.74	40.74
<b>TOTAL</b>		<b>1000</b>	<b>70.7</b>	<b>7.07</b>	<b>7.07</b>

