# Applications of Multi Criteria Decision Techniques and Nature based algorithm to identify the Coastal Vulnerability Index based on Performance, Uncertainty and Reliability of Coastal Surrounding Systems

**Satyabrata Saha** (antusaha84@gmail.com)
National Institute of Technology Agartala https://orcid.org/0000-0003-2848-2403
**Mrinmoy Majumder**
National Institute of Technology Agartala
**Manish Pal**
National Institute of Technology Agartala

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**Authors Details**

Mr. Satyabrata Saha

Research Scholar

Department of School of Hydro Informatics Engineering, (Civil Engg.)

National Institute Technology, Agartala

Jirania, Tripura (W), India

Email: antusaha84@gmail.com

Mobile: +919434493296

**(Corresponding Author)**

Dr. Mrinmoy Majumder

Assistant Professor

Department of School of Hydro Informatics Engineering, (Civil Engg.)

National Institute Technology, Agartala

Jirania, Tripura (W), India

Email: mmajumder15@gmail.com

Mobile: +919830887194

Dr. Manish Pal

Professor

Department of Civil Engineering,

National Institute Technology, Agartala

Jirania, Tripura (W), India

Email: mani_nita@yahoo.co.in

Mobile: +919865034665

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**ABSTRACT**

The Coastal management systems are mainly constitute different subcomponents. The performance of the Coastal surrounding system depends on the performance of these subcomponents. But as pet the previous related studies no attempt was made in identification of the optimal ratio of subcomponent contributions to ensure maximum productivity. Again, there is a lack of scientific endeavors in relation to the determination of the priority of the components in ensuing the coastal vulnerability in coastal management system. The present study will try to identify the priority and optimal ration of contribution required from the components of a Coastal Vulnerability of Coastal Surrounding system. In this regard the advantages of Multi Criteria Decision Making and nature-based algorithms were used and once identified the outcome was validated by a physical model. According to the results of Potential Hydraulic Energy from Wave (PE) and Distance of sea from Coast of a coastal management system most effective for total output. The benefit of adopting this procedure is it approximate the solution not only based on technical aspect but also considering the economic aspect. The results were validated in physical model and concluded that the results has yielded feasible value and the procedure can maximize the performance and minimize the cost requirement to produce a design ensuing maximum productivity. This study also depicts the capacity of Failure Mode Effect Analysis based Multi Criteria Decision Making techniques for the first time which may increase the objectivity and analyticity of an investigation.

***List of Abbreviation:***

MCDM: Multi Criteria Decision Making

CVI: Coastal Vulnerability Index

FMAE: Failure Mode Effect Analysis

AHP: Analytical Hierarchy Process

WSM: Weighted Summation Method

WPM: Weighted Product Model

BFO: Bacterial Foraging Optimization

NBO: Nature Based Optimization Technique

CMS: Coastal Management System

**KEYWORDS**

Coastal Vulnerability Index; MCDM; AHP; Bacterial Foraging Optimization (BFO); Marine Strategy; Coastal Management System;

## 1. INTRODUCTION:

Coastal management is important because due the development of this the natural disaster can be prevent, such as flooding, erosion etc. The Coastal Management act 1972 focused on challenges in coastal area, clean water, and healthy ecosystem. Coastal area consist of 15% area of total land area of earth. Lots of population resides in the coastal area or within 50kms from coastal line (Koroglu et al. 2019). Coastal zones contain valuable resources to produce goods and services and are home to most commercial and industrial activities. Sustainable coastal resource management needs the undertaking and proceeding to next generations of a level and quality of natural resources that will provide a good economic and environmental services. So coastal management is very much important in today's world. In the earlier times to save the coastal region various types of hard engineering or some static structure or heavy structures were implemented, but the process became more costly as well as difficult (Bruno et al. 2020). In current days various types of soft engineering methods are started to apply in the problem solving. In soft engineering various natural resources management given priority, and strategic planning became popular. In the modern days hard engineering as well as soft engineering also became useful technique to manage the coastal vulnerability (Kantamaneni et al. 2018). In soft engineering there are some components are considered to maintain the coastal vulnerability, like available energy potential of ocean wave, distance of sea from the coast, Water quality and Wind speed. A soft technical and strategic analysis is done in this research paper by considering these components of the coastal surrounding system.

## 1.1. MAIN COMPONENTS OF COASTAL SURROUNDING SYSTEMS

In this present study the main components of coastal systems taken as Wave Energy potential at the coastal range $W.E. = \frac{\rho g^2}{64\pi} H_{m0}^2 T_e$; with W.E. the wave energy flux per unit of wave-crest length, $H_{m0}$ the significant wave height, $T_e$ the wave energy period, ρ the water density and g the acceleration by gravity (Tătui and Constantin 2020). This available wave energy striking the coastal area with some vast potential energy, so there may be some kind of energy capturing establishment that can be used as a sustainable renewable energy. So that structure at the coast side can protect the coast from wave strike. Now considering the distances from the sea to coastline take in to consideration. It can estimate the average sea level increase, so the necessary measure can be taken may be any hard engineering or structure be placed (Mullick et al. 2019). Tides also need to monitor by measuring the distances from sea. Water quality is also an important component of coastal management, the total suspended solids, turbidity, salinity, BOD, COD, dissolved solids can affect coastal soil area. Wind speed is an adverse effect to coastal damage, due to wind speed the wave propagation can hit the coast line, high velocity wind can hit the soil of shoreline. Due to wind speed the wave frequency also increase so all these effect can make change in coastal vulnerability (De Serio et al. 2018; San Cristóbal 2011).

The effeteness of the Coastal Vulnerability can be maximized if the loss factors in these sections can be utilized properly. The problem lies in the fact that to identify the ideal value of the factors which can generate maximum efficiency multiple parameters has to be considered as from the next section, it can be concluded that there are approximately various types of losses such that damages various sections, soil characteristics can be observed in different section at the time of regular phase. If all the factors have to be included in the maximization procedure, then the memory requirement and time of convergence will be infeasible and unable to generate any useful solution (Basheer et al. 2016; Vasileiou et al. 2017).

Risks associated with sustainable energy projects depend largely on a number of factors that are technology-, country- and regulatory specific, while they also vary according to different stakeholders' perspectives. Authors working on risk identification, analysis and management in the sustainable energy investment sector have developed different risk categorization schemes according to their intended focus. The most cited risks by employing a political, economic, social, technology, legal and environmental (PESTLE) approach. risks have been analyzed by which methods, what are the common outputs of these methods and which stakeholders have been included in a number of widely cited representative risk-based methodologies applied in sustainable power generation planning and feasibility studies (Meshram et al. 2020). These methods have been classified, for reasons of simplicity, into quantitative and semi-quantitative methodologies. Quantitative risk-based evaluation methods deal with (statistical) risk factors that can be described by probability distributions (Astariz et al. 2017; Zhu et al. 2018).

That is why to resolve this problem and to reduce the dimension of the region of feasibility the present study tried to introduce MCDM techniques which can select the most significant factors for representation of the efficiency of each of the four sections of Coastal Management System. The increase of efficiency will also require satisfying the budget of the project. So optimization of efficiency is required to be conducted under cost constraints.

## 1.2. OBJECTIVE

That is why the main objective of the present study can be delineated as the application of MCDM procedure in selection of most significant factors that can influence the effectiveness of a Coastal Management System (CMS). The feature selection will be followed by a cost constrained maximization procedure which will try to maximize vulnerability by applying cost as constraint. Lastly the study aims to develop a physical model to validate the results from the optimization procedure.

The novelty of the study lies in the fact that for the first time MCDM is used to select the most significant factors which can aptly represent the effectiveness of a CMS as a function of the cumulative efficiency of the four major parameters of the coastal system. Also cost constraint optimization that also by a BFO algorithm is also new and the validation of results by a physical model is rarely attempted in the present field of study.

Section 2 describe the techniques used in the study as a MCDM and optimization process.

# 2. METHODS USED

Here in the present study mainly two types of computational techniques were utilized. MCDM which is described in Section 2.1 and Optimization Techniques as explained in Section 2.2.

### 2.1. Multi-Criteria Decision Making (MCDM):

Multi-Criteria Decision Making (MCDM) gives solutions to the problems involving multiple criteria that which incorporated into the management planning process. AHP is one widely used tool of the MCDM in solving ranking of priorities criteria. AHP offers a frame for structuring a decision problem, for expressing and quantifying its components that helps decision makers to find the best decision suits their goal. The AHP was formulated by Thomas L. Saaty in the 1970s and has been widely used for decision making in many complex choice situations in various field (Boateng et at. 2017; Bonaldo et al. 2019).

Multi-Criteria Decision Making (MCDM) or Multi-Criteria Decision Analysis methods (MCDA), it is a branch of a general category of research models that modify the method of constructing selections within the presence of multiple objectives. In general, MCDM strategies are divided into Multi-Objective decision making (MODM) and Multi-Attribute decision making (MADM). The most distinction between the two teams of strategies is predicated on the determination of alternatives (Tano et al. 2018; Tahri et al. 2017). In MODM, additionally referred to as multi objective programming or a vector optimization / maximization / step-down drawback, the alternatives don't seem to be preset however instead a collection of objective functions is optimized subject to a group of constraints. In MADM, wherever alternatives are preset, a little range of alternatives are to be evaluated against a collection of attributes. The most effective various is typically designated by creating comparisons between alternatives with reference to every attribute (Hoque et al. 2019; Mohd et al. 2019).

A selection coastal site is formed exploitation an equivalent approach. Within the planned AHP methodology, the weights of the selection criteria are determined by pairwise comparison matrices of AHP. In management system decision making problems, the judgments of decision makers are typically imprecise. Because it is comparatively tough for decision makers to supply actual values for the criteria, the analysis information for the alternative energy policies ought to be expressed in linguistic terms (Alsahli and AlHasem et al. 2016).

## 2.2 OPTIMIZATION TECHNIQUE:

Optimization is defined as the method by which an objective function is maximized, minimized or a desired value is achieved by changing the independent variables of the function within a limit of feasibility. The techniques that are followed to change the independent variables is referred as optimization technique. There are various types of techniques or algorithms which are used to change the objective function among which BFO is one of the rarely used but efficient techniques which is inspired by the foraging methodology of bacterium (Maanan et al. 2018; Radmehr et al. 2022). Section 2.2.1 explains the algorithm and its strengths and limitations.

### 2.2.1. BACTERIA FORAGING OPTIMIZATION (BFO)

This Algorithm is a nature inspired optimization algorithm applied in this paper for optimization of mechanical parameters under Coastal Management System. BFO Algorithm was inspired by the social foraging behavior of Escherichia coli and was first proposed by Passino has been applied to many real-world problems and proved its effectiveness over many variants (Passino, 2002). Despite the various advantages of renewable energy, in presents significant drawbacks are present, such as the discontinuity of generation, it depend on the climate, so it requires complex design, planning and control optimization methods (Islam et al. 2016). The continuous advances in computer hardware and software are allowing to deal with these optimization problems using computational resources, as can be seen in the large number of optimization methods that have been applied to the renewable and sustainable energy field. Banos, Raul, Francisco Manzano - Agugliaro, F. G. Montoya, Consolacion Gil, Alfredo

Alcayde, and Julio Gómez present in their research the current state of the art in computational optimization methods applied to renewable and sustainable energy, offering a clear vision of the latest research advances in this field (Mahmood et al. 2020).

Researchers Baskar, J. A., R. Hariprakash, and M. Vijayakumar the minimization of the active losses of the feeder or the minimization of the total network supply costs, which includes generators operation and losses compensation or even the best utilization of the available generation capacity using nature based algorithms (Baskar et al., 6(6): June, 2017; Sekovski et al. 2020).

Section 3 describes the methodology adapted to provide the required solution and maximization of Coastal Vulnerability Index.

## 3. METHODOLOGY:

The methodology of the present study can be subdivided into three major phases. The first phase will be the application of AHP MCDM technique to tangibly select the most significant factors for this application (Chakraborty and Majumder 2019). The second phase will use the strength of the BFO optimization techniques to optimize constrained by cost that will be incurred when the process will be initiated and aggravate with the process of iterations. In the last phase a physical model was developed to verify the results produced by the optimization procedure. Section 3.1 to 3.3 depicts the procedures at a greater depth.

### 3.1. APPLICATIONS OF ANALYTICAL HIERARCHY PROCESS, WEIGHTED SUMMATION METHOD (WSM) WEIGHTED PRODUCT MODEL (WPM):

The AHP, WPM, WSM MCDM method were applied to estimate the significance of the components of a CMS. The significance was determined with respect to its role in ensuing performance, providing reliability and avoiding uncertainties of the coastal surroundings system (De Serio et al. 2018; Elshaboury et al. 2020). The components are compared to each other with respect to performance, reliability and uncertainty as criteria. At first the components were sorted in descending order of importance based on each criterion. This descending order was decided with the help of Eqn.1.

For Performance criteria:

$$P = \frac{CVI}{(E \times L \times T)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where

CVI = Observed effectiveness of the component / rated effect of the components for coastal surrounding system.

E = Observed expenditures incurred for installation, operation and maintenance of the component / rated expenditures incurred for installation, operation and maintenance of the component for coastal surrounding system

L = Observed lifespan of the component / rated lifespan of the components for coastal surrounding system

T = Observed time in use of the component / rated time in use of the components for coastal surrounding system

The components were sorted with respect to reliability by adopting the FMAE analysis of the components whereas the uncertainty analysis were derived by the Thiel's Uncertainty Equation and here as the criteria is a non-beneficiary with respect to the goal of the present MCDM problem, an ascending order of the components were made with the help of uncertainty probability of each component for the CMS. Like Eqn.1 here also the uncertainty of the component of the selected CMS was normalized with respect to the rated uncertainty of the similar type of converters. The benefit of this normalization is it reduces the impact of scale factor on the calculations.

The order of the components was used to estimate the pairwise comparison matrix of the alternatives with respect to that criteria.

The weightage of the components (*i.e., u, v, w and x*) was also approximated by WSM and WPM MCDM methods and the ensemble of the output from all these three methods were used as the weightage of significance for the components (Kantamaneni et al. 2018; Meshram et al. 2020). Section 3.2 depicts the procedure by which the conversion efficiency can be maximized. The main objective was to find the optimal ratio of contribution of components which can yield maximum productivity from the coastal management. Here cost of operation was used as constraints.Fig.1 shows the schematics of the proposed procedure.Fig.2 depicts the decision hierarchy for the MCDM phase.

## 3.2 APPLICATION OF BACTERIAL FORAGING TECHNIQUE NATURE BASED OPTIMIZATION TECHNIQUE

The main aim of the present study was to find the optimal ratio of contribution from the four different components of a DISTANCE OF SEA. The "Contribution" here is assumed to be the operational efficiency of the components. To find the optimal ration the significance of each component was first approximated by the objective method of MCDMs as described in Section 3.1. After the significance approximation an objective equation was developed which was maximized to find the optimal ratio of contribution of the components for which maximum productivity can be achieved from the CMS. Eqn.2 depicts the equation.

$$Maximize\ CVI\ = Coastal\ Vulnerability : u \times PE\ +\ v \times DT\ + w \times WQ\ +\ x \times WS \ldots\ldots\ldots (2)$$

$Subject\ to$

$u, v, w\ and\ x\ will\ be\ equal\ to\ as\ determined\ by\ Eqn. 1$

$$Lower\ limit\ of\ operational\ budget\ < \pi\{(PE, DT, WQ, WS) \times (C_1, C_2, C_3, C_4)\}$$
$$< Higher\ Limit\ Operational\ Budget$$

$$Or$$

$$0 < \pi\{(PE, DT, WQ, WS) \times (C_1, C_2, C_3, C_4)\} < 1$$

*Such that:*

$$\sum (PE, DT, WQ, WS) = 1$$

$$\sum (C_1, C_2, C_3, C_4) = 1$$

*Where*

$u, v, w\ and\ x$ Represents the weightage of significance of the components Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast (DT), Water Quality (WQ), and Wind Speed (WS) respectively.

$PE, DT, WQ, WS$ These are the magnitude of operational efficiency of the components Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast (DT), Water Quality (WQ), and Wind Speed (WS) respectively.

$(C_1, C_2, C_3, C_4)$ These are the operational cost required for generating the $PE, DT, WQ, WS$ unit of efficiency from the Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast (DT), Water Quality (WQ), and Wind Speed (WS) respectively.

$PE, DT, WQ, WS$ are the normalized value of the operational efficiency of the components with respect to the summation of operational efficiency of all the components whereas $C_1, C_2, C_3, C_4$ are the per unit operational cost incurred to produce $PE, DT, WQ, WS$ unit of productivity from the Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast (DT), Water Quality (WQ), and Wind Speed (WS) respectively..

The optimization of coastal vulnerability index CVI was executed by two different methods; BFO and the attributes like time to convergence, minimum, maximum and average value of CVI as approximate by the two different optimization techniques were compared to find the best method of optimizing the present objective and the magnitude of optimization that can be achieved by satisfying the constraints on the design or changing variables.

From the Eqn.*2* it can be observed that $(PE, DT, WQ, WS)$are the design variables on which the cost constraints$(C_1, C_2, C_3, C_4)$ were applied. The optimal value of CVI must be obtained within the region of feasibility indicated by the cost constraints of the four design variables (Chakraborty and Majumder 2019; Chakraborty and Majumder 2020).

The model results were validated with the help of a physical model which replicate a Coastal System with the help of a flume based experimental setup. Section 3.3 describe about the experimental setup and Fig.3 depicts the physical model developed for the replication.

### 3.3. DEVELOPMENT OF PHYSICAL MODEL

In case of the development of the physical model the main objective was to produce an experimental replication of a coastal management and surrounding system. As shown in Fig.3 a flume of 5m long and 0.5m width and 0.5m depth was developed in a laboratory environment.

In the flume using various sizes of sand and mud particles an artificial coast was developed was attached in one end to the bed of the flume (See the Side view of the flume in Fig. 3). The sand made coastal look like obstruction was placed in a horizontally manner in the flume in such a way that the flow from the source side of the flume will comes and diffracted and diverged into the sand portion.

A small hydraulic piston was installed at the source side of the flume which was used to generate regular waves at 15 sec intervals. The sand made coast, due to the flow in the flume started to hit by the wave propagated, and sand erosion noted.

Here in the present investigation, the analogy of wave frequency was compared with distance of the coast from sea, whereas the flow of water through the flume was compared with the potential hydraulic energy of the system.

A pump and a reservoir is present side of the flume which ensure the continuous supply of water at the source section. The results were not only validated from the experimental setup but it was also validated by the output from a real Coastal surrounding systems. The coastal situation of real field was visited at Bay of Bengal. The location was taken at 21°37'41.7"N 87°32'24.6"E. (nearby area of Bay of Bengal).

The objective of the physical model is to replicate the natural system of ocean - coast interactions. The Nature to Lab arrangement is made by the following materials:

1) Flume: 3m × 2m × 1m (Whole Dimension); Working Dimension 2m × 2m × 1m.

2) Piston

3) Sand

4) Lab Water mixed with commercial salt in ratio of 100:3.5 (one lit water: 35gm salt)

5) Pedestal Fans with Controller Rating

The scale factor of replication is $1/10^{th}$

The Flume was almost 25% filled with water and market salt was mixed with a ratio of 3.5:100, i.e. 35gm salt mixed with 1 Liter of water to maintain the salinity of water similar to ocean water. This saline water experiment continued only few days, because the corrosive effect on the equipment. The same test was also done with the normal water for a several weeks. The pedestal fan was blowing to maintain the wind flow over the water surface maintain the wind speed. By using electrical variac, speed of the fan was controlled from low to high and high to low for varying the wind speed. The piston was used to create short waves in different time frame. Equations 3a and 3b in terms of the displacement in piston ($x_p$) and its capacity to generate waves of height H within a time *t*.

$x_p(t) = \frac{H}{k}\left(\tanh x(t) + \tanh\frac{k}{d}\lambda\right)$………………… (3.a)

$x(t) = \frac{k}{d}\left(ct - x_p\,(t) - \lambda\right)$……………………….. (3.b)

Where $H$ is the wave height, $k = \sqrt{\frac{3H}{4d}}$ and Celerity$c = \sqrt{g(d+H)}$, $x_p(t)$ is the displacement of the piston, *d* is the depth, $= \frac{d}{k}$ . Wave generation was regulated by the piston movement.

This same procedure was done for creating different wave related studies in the lab.

| **Parameter** | **Analogy** |
|---|---|
| Potential Hydraulic Energy | Force Generated by Piston |
| Distance from Coast | Distance from Sand Bed |
| Water Quality of Sea Water | Water Quality of the Lab Water. Salt mixed to enhance salinity |
| Wind Speed | Imposed by Pedestal Fan |

Table 1: The parameters taken into consideration and the analogy done for those parameters in lab setup.

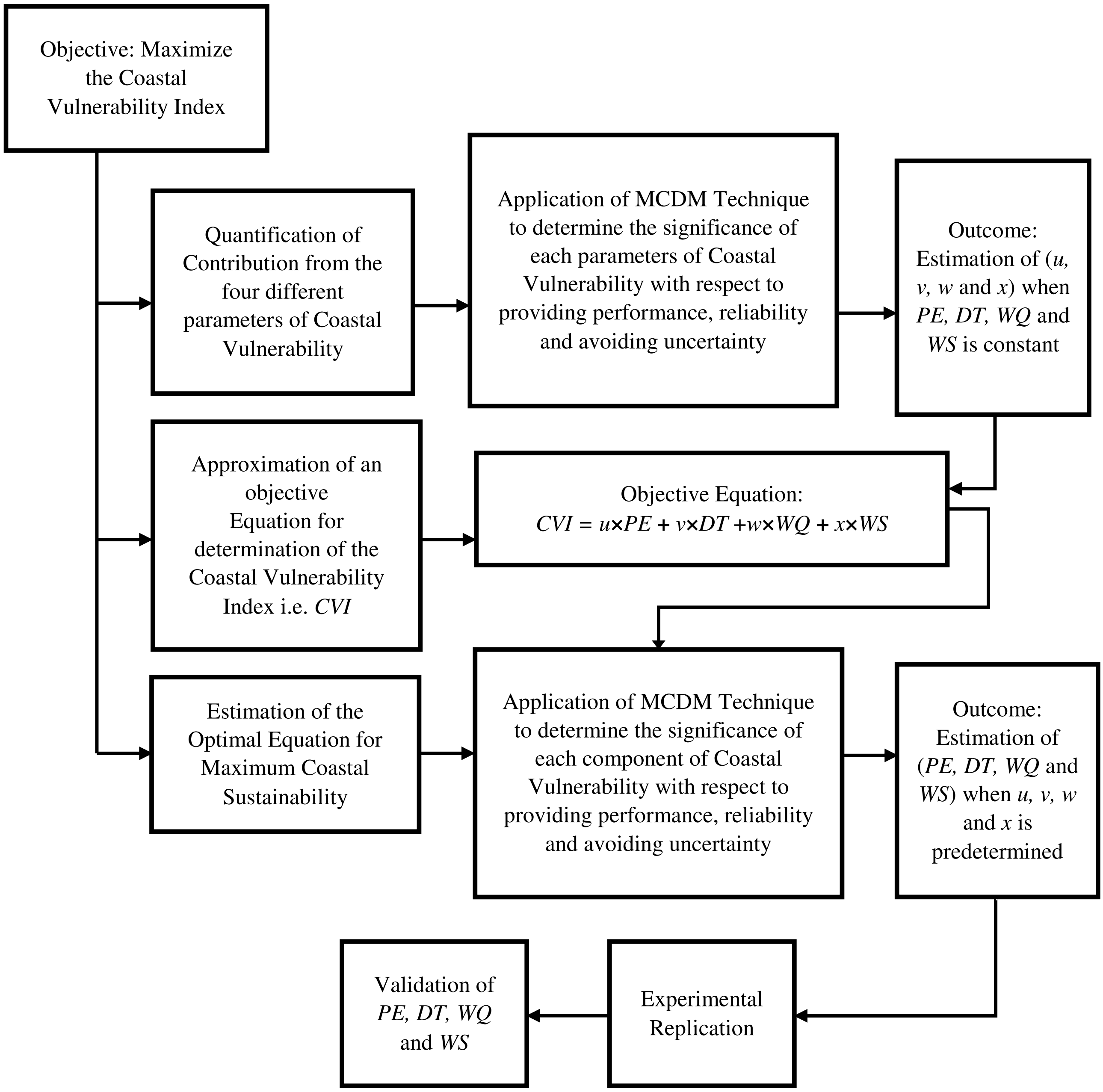


Fig.1.Figure showing the schematic diagram of the study methodology

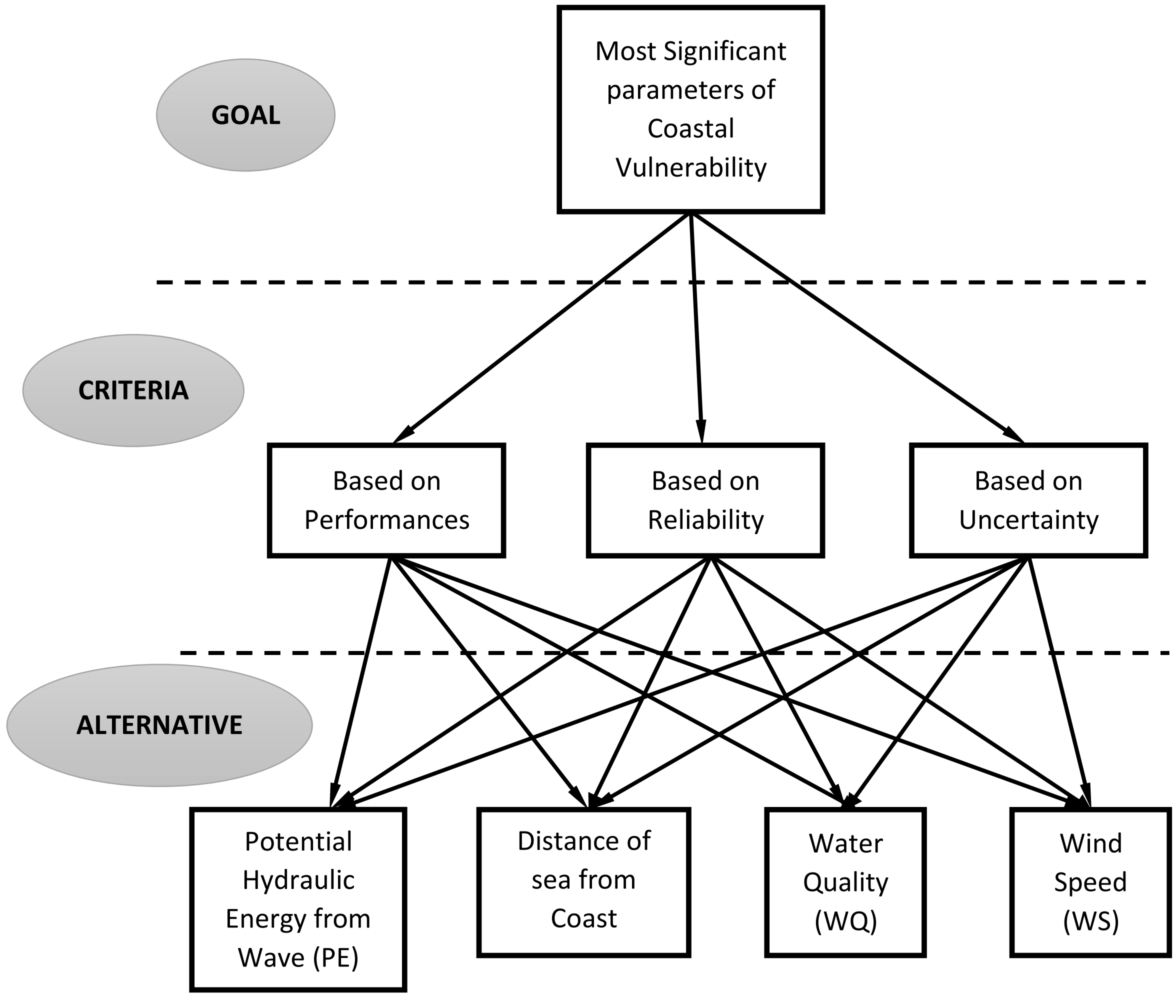


Fig.2.Figure showing the Decision Hierarchy

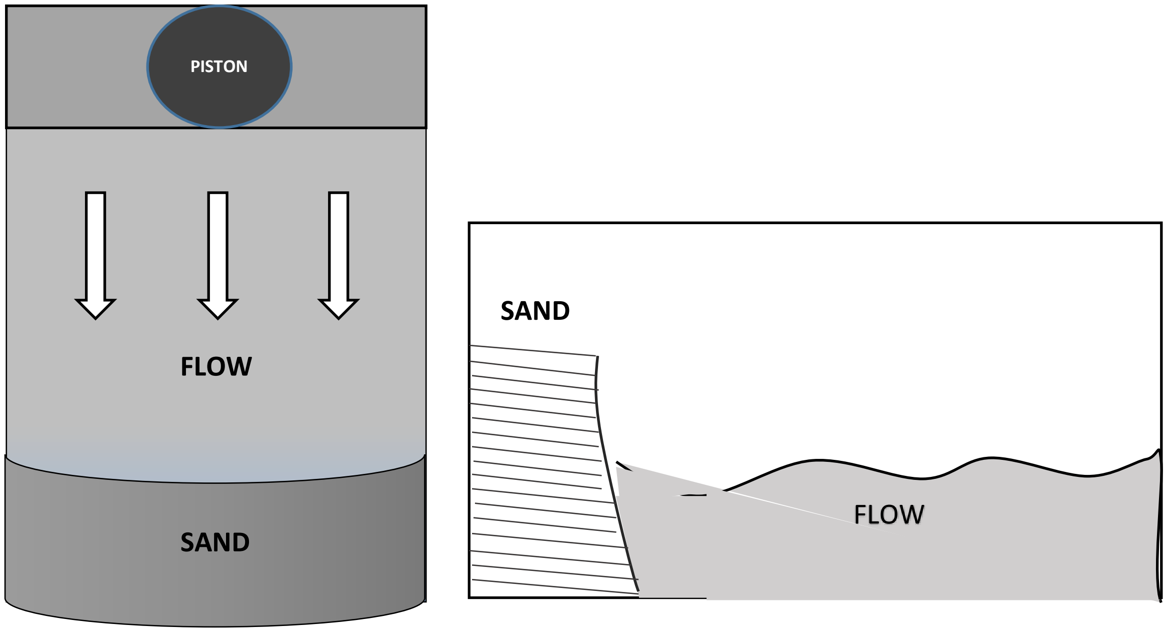


Fig.3.Figure showing the layout of the experimental setup to replicate the Coastal Vulnerability Index Testing

## 4. RESULTS AND DISCUSSION

The four parameters discussed over each other are generated through literature. The pair-wise comparison metric of three criteria's (Performance, uncertainty, and reliability) importance and their normalized values are shown in Table 2. The normalized weight of Performance, uncertainty, and reliability by AHP are estimated to be 0.4406, 0.2448 and 0.3147 respectively (Table 2). Normalized weight and relative Priority Value of the four parameters by AHP are shown in Table 3. The normalized weight of Hydraulics Section, Pneumatic Section, Mooring Section, and Power Take off Section by AHP are found to be 0.2572, 0.2581, 0.2429 and 0.2418 respectively.

The normalized priority values of the three-criterion uncertainty productivity and reliability are found to 0.4406, 0.2448 and 0.3147 respectively.

| Criteria | Score | Performance | Reliability | Uncertainty | Normalized Weight |
|---|---|---|---|---|---|
| Performance | 5 | 1.00 | 1.80 | 1.40 | 0.4406 |
| Reliability | 9 | 0.56 | 1.00 | 0.78 | 0.2448 |
| Uncertainty | 7 | 0.71 | 1.29 | 1.00 | 0.3147 |

Table 2: Pair-wise comparisons of three criteria importance and their normalized values

The components Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast (DT), Water Quality (WQ), Wind Speed (WS).

| Parameters | Performance | Reliability | Uncertainty | Criteria Weight | Normalized Weight |
|---|---|---|---|---|---|
| PE | 0.2463 | 0.2589 | 0.2711 | 0.4406 | 0.2572 |
| DT | 0.2593 | 0.2319 | 0.2767 | 0.2448 | 0.2581 |
| WQ | 0.2565 | 0.2704 | 0.2023 | 0.3147 | 0.2429 |
| WS | 0.2379 | 0.2387 | 0.2499 | × | 0.2418 |

Table 3: Normalized weight of four parameters (AHP)

The normalized priority values of the three-criterion uncertainty productivity and reliability are found to 0.4406, 0.2448 and 0.3147 respectively.

| **WSM** | Performance | Reliability | Uncertainty | Sum | Normalized Value |
|---|---|---|---|---|---|
| Criteria Wt | 0.4406 | 0.2448 | 0.3147 | | |
| PE | 0.2463 | 0.2589 | 0.2711 | 0.25721 | 0.25719 |
| DT | 0.2593 | 0.2319 | 0.2767 | 0.25809 | 0.25807 |
| WQ | 0.2565 | 0.2704 | 0.2023 | 0.24287 | 0.24285 |
| WS | 0.2379 | 0.2387 | 0.2499 | 0.24190 | 0.24188 |
| | | | | 1.000076 | 1 |

Table 4: Normalized weight of four parameters WSM method

| **WPM** | Performance | Reliability | Uncertainty | Sum | Normalized Value |
|---|---|---|---|---|---|
| Criteria Wt | 0.4406 | 0.2448 | 0.3147 | | |
| PE | 0.2463 | 0.2589 | 0.2711 | 0.25693 | 0.25763 |
| DT | 0.2593 | 0.2319 | 0.2767 | 0.25748 | 0.25818 |
| WQ | 0.2565 | 0.2704 | 0.2023 | 0.24110 | 0.24175 |
| WS | 0.2379 | 0.2387 | 0.2499 | 0.24178 | 0.24243 |
| | | | | 0.997291 | 1 |

Table 5: Normalized weight of four parameters WPM method

The minimum, maximum and average predicted sub-index and index value of Coastal Vulnerability Index system using BFO Algorithm are shown in Table 4. The minimum, maximum and average predicted CVI values found by BFO Algorithm are 1.859, 2.334 and 2.097 at iteration numbers 2000, and 6000.

| Ratio | Iteration No. | PE | DT | WQ | WS | Objective Function |
|---|---|---|---|---|---|---|
| Minimum Value | 2000 | 0.183 | 0.093 | 0.129 | 0.244 | 1.859 |
| Maximum Value | 6000 | 0.144 | 0.179 | 0.111 | 0.146 | 2.334 |
| Average Value | All | 0.148 | 0.149 | 0.140 | 0.138 | 2.096 |

Table 6: Predicted value sub-index and index of CVI using BFO Algorithm

**CONCLUSION:**

The present study attempted to approximate the optimal ration of contribution from the different component of a Coastal surrounding system to produce maximum sustainability which will be feasible under the budgetary limitations. Accordingly, the study utilized the feature selection ability of ensemble MCDMs and optimization capability of BFO for achieving the objective of the present investigation. The results were validated by a physical model where the functionary component of a coastal system was replicated in a laboratory prototype. According to the results higher priority of Potential Hydraulic Energy from Wave (PE), Distance of sea from Coast can affect the overall performances of power generation. Although the result of the study has two significant contribution towards the system sustainability, the methodology proposed here also enforced some assumptions. The novelty lies in the fact that this is the first time MCDM was used with FMAE method to identify the contributions of each component of the coastal management system which was also not attempted in previous studies in an objective manner. Another novelty of the present study is the attempt to identify the optimal ratio and validating the same with physical model such that the same ration can be implemented for maximum vulnerability of coastal system. As the cost is utilized as constraints the result will be practically implementable in real life. Another benefit of the study includes that the objective equation can now be utilized to identify optimal design of the Coastal management system which will help to innovate new type of costal development systems. The limitations of the present investigation included the probability of change in the ideal ratio when new optimization technique or MCDM methods are introduced. Although the rank of dominance will be same as the sorting were conducted by following objective and repeatable methodologies but with the implementation of new techniques the results will change. This problem can be avoided if uniform policy for determination of ideal ration is followed by a regulatory or governing body of the locations where the coastal system is proposed to be installed. Another assumption of the study is although the operational cost was considered while identifying the ideal ration but the approximated magnitude of the component contribution can be hard to replicate in real life due to other constraints like geometric, logistic or availability of the component design required to replicate the ratio as identified by the optimization technique. That is why the study can also be re-executed with geometric, logistic and availability constraints but such limitations will elongate the time of convergence and also the search domain will be constricted and thus the ideal solution may fall outside the region of acceptance. Another impact of this modification will be the requirement of high end memory based computational systems.

**Declarations**

1. Ethical Approval:

- The manuscript should not be submitted to more than one journal for simultaneous consideration.

  **Answer: Not submitted.**

- The submitted work should be original and should not have been published elsewhere in any form or language (partially or in full), unless the new work concerns an expansion of previous work. (Please provide transparency on the re-use of material to avoid the concerns about text-recycling ('self-plagiarism').

  **Answer: The submitted work is original and the work not has been published elsewhere.**

- A single study should not be split up into several parts to increase the quantity of submissions and submitted to various journals or to one journal over time (i.e. 'salami-slicing/publishing').

  **Answer: Not done.**

- Concurrent or secondary publication is sometimes justifiable, provided certain conditions are met. Examples include: translations or a manuscript that is intended for a different group of readers.

  **Answer: Not applicable.**

- Results should be presented clearly, honestly, and without fabrication, falsification or inappropriate data manipulation (including image based manipulation). Authors should adhere to discipline-specific rules for acquiring, selecting and processing data.

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2. Consent to Participate:

   **All the authors have given their consent for participating in this research work.**

3. Consent to Publish:

   **All the authors have given their consent for publishing this research work.**

4. Authors contribution:

   The study, concept and design, material preparation, data collection, analysis, writing of manuscript were performed by Satyabrata Saha, Dr. Mrinmoy Majumder and Dr. Manish Pal. All authors read and approved the final manuscript.

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7. Availability of data and materials:

   **Source of data has been clearly mentioned in the manuscript.**

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