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# Sand Dredging and Management of Dredged Material

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**ABSTRACT:** Sand dredging plays a vital role in various sectors such as construction, coastal engineering, and land reclamation, yet it poses significant environmental challenges. This research focuses on sand dredging processes and dredged material management to mitigate environmental impacts and ensure sustainable resource utilization. The study explores dredging technologies, environmental regulations, sediment dynamics, and disposal options for dredged material. It also examines emerging technologies and innovative reuse methods like beach replenishment, ecosystem restoration, and land reclamation. Stakeholder engagement, environmental monitoring, and adaptive management are emphasized for responsible and effective dredging project outcomes. The study includes detailed analyses of sand dredging techniques and sediment prevention methods, based on two case studies and 67 responses. Findings reveal a 37% reduction in project execution time through sediment prevention measures, showcasing the practical benefits of proactive strategies. Furthermore, the management of sedimentation in reservoirs is crucial for dam efficiency. Early intervention using empirical formulas aids in sedimentation rate prediction and targeted preservation efforts. Water Injection Dredging is highlighted as an efficient and cost-effective technique, though its success depends on reservoir conditions and sediment characteristics. The study suggests constructing dedicated Water Injection Dredgers for large reservoirs to optimize sediment removal, reducing reliance on external contractors and adapting to seasonal water levels. Combining this technique with others like Mechanical Excavation enhances overall effectiveness. In conclusion, proactive sediment management strategies, especially leveraging Water Injection Dredging, are essential for sustaining reservoir functionality. Customized, adaptive approaches considering reservoir size and sediment characteristics optimize cost-efficiency and long-term preservation. This research underscores the importance of innovative technologies and adaptive management for responsible sand dredging and dredged material management practices.

**KEYWORDS:** Sand dredging, dredged material management, Environmental impact, Sustainable resource utilization, Dredging methods.

## I. INTRODUCTION

Sand dredging is an essential part of managing riverine and coastal resources since it shapes the terrain and facilitates a range of human endeavours. The growing need for this necessary building material is what propels the removal of sand from riverbeds and coastal regions. Sand dredging, however, poses serious environmental risks, including destruction of habitats, erosion, and deterioration of water quality. Maintaining the biological integrity of aquatic ecosystems while satisfying the demands of society for building materials requires effective management of dredged material. This entails putting into practise environmentally friendly dredging procedures, using cutting-edge technology, and creating solid plans for the advantageous reuse of dredged material. Understanding and resolving the environmental effects of sand dredging is essential for the appropriate and sustainable use of this essential natural resource as societies work towards economic growth. Managing dredged material requires balancing a number of intricate factors, including economic, regulatory, and environmental ones. If dredged debris is not disposed of carefully, it may have a significant impact on aquatic and terrestrial ecosystems. Innovative solutions are being used, such as the advantageous repurposing of dredged material in land reclamation, building, and restoration projects. These methods lessen the environmental impact of dredging operations while supporting sustainable development by turning what was before thought of as garbage into a useful resource.

Social and economic aspects are just as important to the efficient handling of dredged debris as environmental ones. The lives of local residents often depend on water bodies, and the repercussions of sand dredging might go beyond the

immediate ecological implications. Sand extraction has economic advantages, but maintaining the integrity of ecosystems is also important. To achieve this, a complete strategy that includes community involvement, environmental impact assessments, and strict regulatory compliance is needed. The accuracy and effectiveness of sand dredging operations are also greatly enhanced by technological developments in dredging machinery and monitoring instruments. Operators can optimise dredging procedures and reduce disruption to aquatic environments by using real-time data gathering and analysis. Furthermore, a step in the right direction towards reducing the negative environmental effects of sand extraction is the development of environmentally friendly dredging technology, such as suction dredgers that lessen sediment resuspension.

### 1.1 Challenges and Concerns in Sand Dredging

#### • **Ecological Consequences: Assessing the Impact on Marine Ecosystems**

An essential operation for many sectors, sand dredging presents a number of difficulties and worries, especially with regard to its environmental effects. The process of sand mining has a significant impact on marine ecosystems, particularly as demand for the material rises. Dredging activities may generate disturbances that change the topography of the seabed, which can result in the loss of habitat for a variety of marine species. Furthermore, sediment discharge into the water may have a detrimental effect on the quality of the water, harming aquatic life and upsetting the fragile ecosystem's equilibrium. Ensuring sustainable sand dredging practises that minimise damage to marine habitats requires an understanding of and commitment to minimising these ecological impacts.

#### • **Regulatory Frameworks: Navigating the Complexities of Dredging Laws**

The intricate regulatory frameworks that govern the sand dredging sector provide additional difficulties for the operation. A thorough awareness of environmental, social, and economic aspects is necessary to navigate the complexities of dredging rules and regulations at the local, national, and international levels. Sustainable and ethical sand mining depends on legal compliance; nevertheless, due to the heterogeneous and sometimes incompatible character of these frameworks, regulatory agencies and industry players may encounter difficulties. Developing and enforcing effective dredging legislation requires striking a balance between promoting economic growth and protecting environmental concerns. In order to promote a responsible and transparent sand dredging sector that is in line with environmental conservation objectives, it is imperative to address these legislative complications.

### 1.2 Management of Dredged Material

#### 1. Dredged Material Characteristics: Understanding Composition and Properties

Understanding the composition and qualities of dredged material thoroughly is the first step towards its effective treatment. The type of dredged material varies greatly and might include organic debris, sediments, and even pollutants. Making educated judgements about disposal or advantageous reuse requires a thorough analysis of these features. The distribution of grain sizes, the chemical makeup, and the presence of contaminants are important variables.

- **Grain Size Distribution:** Determining the dredged material's transit and settling properties requires analysing the range and distribution of particle sizes in the material. Fine sediments may affect the quality of water and provide sedimentation difficulties.
- **Chemical Composition:** Determining the chemical makeup of dredged material is crucial for evaluating possible environmental effects. Factors like nutrients and heavy metals might affect a material's appropriateness for certain disposal or reuse scenarios.
- **Pollutant Presence:** Pesticides, hydrocarbons, and other contaminants must be found and measured in dredged material in order to comply with regulations and reduce ecological concerns.

#### 2. Innovative Approaches: Sustainable Solutions for Dredged Material Utilization

Creative methods of using dredged material are essential to the goal of sustainable resource management. Using dredged material for productive applications might help save the environment and improve resource efficiency rather than seeing it as a waste product.

- **Land Reclamation:** Dredged material may be used to land reclamation operations, offering chances to establish new ecosystems, recreational spaces, or even improve resistance to coastal hazards. When implemented effectively, this strategy reduces the need for further natural resource exploitation.
- **Erosion Control:** The impacts of coastal erosion may be lessened by placing dredged material strategically. This is a developing problem. Dredged material may be used to reinforce shorelines, preventing or slowing erosion and protecting important coastal habitats.



- **Capping Contaminated Sites:** Pollutants may be isolated and kept from leaking back into the environment by capping polluted sediments with suitable-quality dredged material. This strategy aids in the cleanup of contaminated regions.
- **Beneficial Reuse in Construction:** Dredged material may be used in building projects, for example, in the production of building materials or as a part of engineered soils. This strategy encourages the sustainable use of resources in line with the circular economy's tenets.

## II. RESEARCH METHODOLOGY

The methodology for sand dredging and the management of dredged material involves a systematic approach to ensure the sustainable extraction of sand resources while minimizing environmental impact. The process typically begins with a comprehensive site assessment, including surveys and sampling, to determine the optimal locations for dredging and to understand the characteristics of the sediments involved. This initial data collection is crucial for developing an efficient dredging plan that targets areas with the desired sand quality and quantity. Once the dredging locations are identified, the selection of appropriate dredging equipment and techniques becomes paramount. Various dredging methods, such as cutter suction dredging or trailing suction hopper dredging, may be employed depending on the specific site conditions and project requirements. The equipment used should be carefully calibrated to extract the necessary amount of sand while minimizing turbidity and disturbance to the surrounding ecosystem. Simultaneously, effective management of dredged material is a key component of the methodology. This involves the classification of dredged material based on its composition and potential contaminants. Clean, non-contaminated sediments may be suitable for beach nourishment or habitat restoration, while contaminated material may require special handling or disposal methods to prevent environmental harm. Environmental monitoring is an integral part of the methodology to assess the impact of dredging activities on water quality, marine life, and the surrounding ecosystem. This includes real-time monitoring of sediment dispersion, turbidity levels, and the potential release of contaminants. Adaptive management strategies should be implemented based on the monitoring results to adjust dredging practices and mitigate any unforeseen environmental effects.

Community engagement and regulatory compliance are also essential aspects of the methodology. Consultation with local communities, stakeholders, and regulatory bodies helps ensure that the sand dredging activities align with environmental regulations and address concerns of the affected parties. Regular reporting and transparent communication throughout the dredging process contribute to building trust and fostering sustainable practices in the management of dredged material. Overall, the methodology for sand dredging and dredged material management integrates scientific assessments, technological considerations, environmental monitoring, and stakeholder engagement to achieve a balance between resource extraction and environmental conservation.

### 2.1 Research Design

#### 1. Case Study Details

##### A. Case Study: Sand Dredging at Mrica Reservoir

The Mrica Reservoir, located in a scenic region of Africa, has faced challenges with sedimentation over the years, necessitating sand dredging to maintain operational capacities. The reservoir's geography and sediment composition have influenced the management strategies employed. To effectively address sedimentation, a comprehensive dredging operation was initiated. A primary component of this operation involved deploying a sophisticated dredging pipeline system. The onshore pipeline stretched an impressive 9000 meters, while an additional 1000-meter-long floating pipeline was strategically positioned to facilitate efficient dredging across the reservoir.

The operation required two booster stations strategically positioned along the 10,000-meter pipeline to maintain optimal material transport. Calculations for the dredging project costs were based on established CIRIA (Construction Industry Research and Information Association) standards, which factored in pipeline length, material transport requirements, and booster station placements. An essential aspect of the project was the assessment of weekly production costs, which varied based on operational factors such as dredging volume and equipment efficiency. This analysis informed ongoing budgetary considerations and resource allocation throughout the dredging campaign. The Mrica Reservoir case study underscores the importance of effective sediment management through advanced dredging technologies and operational strategies. By implementing a robust dredging system with careful cost analysis and logistical planning, the reservoir's operational integrity and environmental sustainability were successfully maintained.



Figure No.1 Google Map Sand Dredging at Mrica Reservoir

### B. Millsite Reservoir

The second reservoir that has been investigated is the Millsite Reservoir. This reservoir is located in the state Utah, in the United States of America. It is situated close to Ferron City and has been constructed in 1971. The original storage capacity of the reservoir was 22.2 million cubic meters and the purpose of the reservoir was to fulfil irrigation needs of the local community. Sedimentation in the reservoir has led to a capacity decrease of 3.2 million m<sup>3</sup>, which coincides with a capacity decrease of 14%. This means that the yearly capacity decrease of the Millsite Reservoir is 0.44%. The primary function of the reservoir is going to be harmed if this decrease of reservoir capacity continuous. Therefore, measurements to counteract this sedimentation process have to be investigated in order to maintain the current reservoir capacity and possibly restore the original capacity. The Millsite Reservoir is much shorter and smaller than the Mrica Reservoir. The average steepness of the Millsite Reservoir is 0.014, which is steeper than the Mrica Reservoir. The water level is partly brought down in the satellite picture, which makes the sedimentation at the river mount clearly visible.



FigureNo.2 Satellite Picture of the Millsite Reservoir (Google Earth, 2012)

To investigate which reservoir preservation method is suitable for this particular reservoir, the reservoir needs to be categorized and the sedimentation problem needs to be quantified. These steps are discussed in the following paragraphs, where also the Water Injection Dredging option will be evaluated.

### 2.2 Sampling Strategy

Sand dredging and the management of dredged material are critical activities that can have significant environmental impacts. When assessing these impacts, an effective sampling strategy is essential to gather representative data and insights.

In this context, a robust sampling strategy should be employed to ensure that the collected data accurately reflects the conditions and effects associated with sand dredging operations. The following approach outlines a suitable sampling strategy:

**1. Sample Size and Selection:**

- The sample size chosen for this study is 67. This number is determined based on statistical considerations to achieve a representative dataset.
- The sampling strategy includes both random sampling and stratified sampling techniques.

**2. Random Sampling:**

- Random sampling involves selecting samples from the population in a way that each unit has an equal chance of being selected.
- For sand dredging impacts, random sampling can be used to select sampling locations along the dredging site or in areas influenced by dredging activities. This helps in capturing a broad range of conditions without bias.

**3. Stratified Sampling:**

- a. Stratified sampling involves dividing the population into subgroups (strata) based on certain characteristics (e.g., depth of dredging, proximity to shore, sediment type).
- b. Each stratum is then sampled separately with random sampling techniques applied within each stratum. This ensures that each subgroup's characteristics are adequately represented in the sample.

**2.3 Questionnaire Survey**

In addition to physical sampling, a questionnaire survey can complement the data collection process by gathering perspectives and feedback from stakeholders, experts, or individuals affected by sand dredging activities.

**1. Respondent Selection:**

- The survey will target 67 respondents, carefully selected to represent a diverse range of stakeholders, including environmental experts, local communities, regulatory authorities, and dredging industry professionals.
- The selection of respondents will be stratified to ensure a balanced representation of opinions and expertise.

**2. Questionnaire Design:**

- The questionnaire will be designed to gather insights on various aspects related to sand dredging and dredged material management, such as environmental impacts, regulatory effectiveness, and community perceptions.
- Questions will be structured to elicit specific and actionable feedback to inform policy and decision-making processes.

By employing a combination of robust sampling strategies, including random and stratified sampling techniques alongside a targeted questionnaire survey, this study aims to provide comprehensive insights into the impacts and management of sand dredging and dredged material. This data-driven approach will support evidence-based decision-making and facilitate sustainable practices in this critical aspect of coastal management.

### III. RESULT AND DISCUSSION

Sand dredging is a critical activity for maintaining navigational waterways and replenishing beaches. However, it can impact aquatic ecosystems and sediment dynamics. Managing dredged material is key to sustainable practices. Analytical studies assess the environmental, economic, and social impacts of dredging operations, optimizing sediment removal while minimizing ecological disturbance.

MRICA RESERVOIR

Table .1 Distribution of Sediments in The Mrica Reservoir

Sediment classification	Grain size [mm]	Distance in reservoir from reference point [km]
Clay	< 0.005	0 – 1.1
Mud/Silt	0.005 – 0.05	1.3 – 2.5
Fine to coarse sand	0.05 – 2.0	2.5 – 9.0
Fine to coarse gravel	2.0 – 60	9.0 – 9.2
Pebbles or coral stone	> 60	> 10

5.1.1 Classify The Mrica Reservoir Based On the Empirical Area-Reduction Method

The first classifying method applied on the Mrica reservoir is the Empirical Area-Reduction method. The basic of this method is the shape of the reservoir and the method divides the reservoir into 4 different shapes. The shape is determined by the parameter “M”, which is the reciprocal of the slope of the line obtained by plotting the reservoir depth at the vertical axis against the reservoir capacity at the horizontal axis on log-log paper. The parameter M can be now being calculated for the Mrica reservoir. The first point that can be plotted on the log-log paper is the point with the Reservoir Capacity  $140 \cdot 10^6 \text{ m}^3$  and the proportional Reservoir Depth of 95 meter. The second point that is necessary for the plot has to be calculated and interpolated from the longitudinal profile of the reservoir:

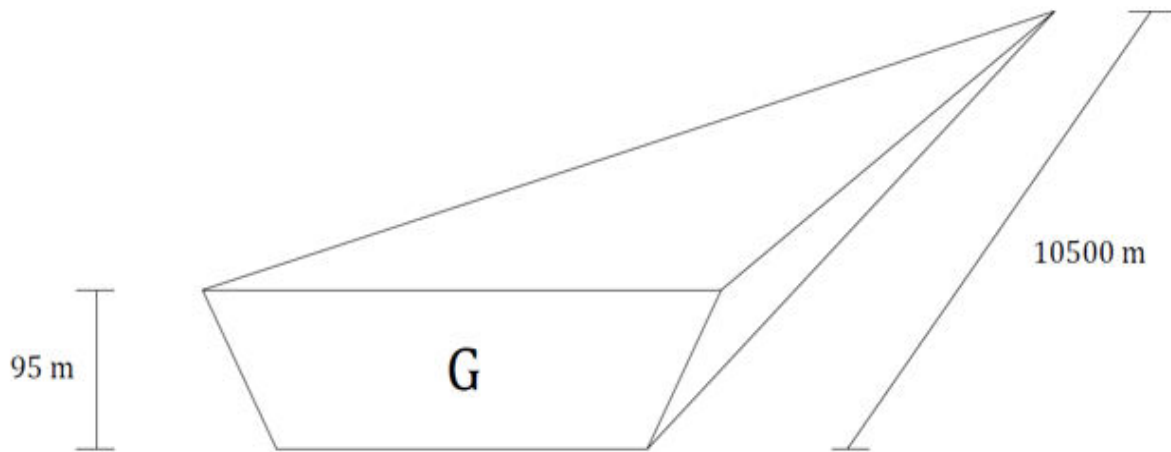


Figure No.3 Schematization of The Mrica Reservoir

The assumed simplified profile of the Mrica reservoir is presented in Figure 25, where G represents the ground surface of the schematised pyramid. The total volume of the reservoir  $V$  is  $140 \cdot 10^6 \text{ m}^3$ , when the depth of the reservoir is 95 m. The length  $L$  of the reservoir is 10.500 meter.

The surface of  $G$  is then:

$$V = \frac{1}{3} GL$$

$$140 \cdot 10^6 = \frac{1}{3} G \cdot 10.500$$

$$G = 40 \cdot 10^3 \text{ m}^2$$

To plot the line on the log-log paper, the volume of the reservoir at a certain depth has to be calculated. The depth of 40 meter is chosen, where it is assumed that the profile of the volume has the same shape as the profile on the 95 meters' depth. From detailed measurements results that the proportional length of the reservoir at 40 meters' depth is 3400 meter.

Because it is assumed that the shape of the reservoir at 40 meters' depth is the same as the shape of the reservoir at 95 meters' depth, the ratio between the two shapes can be used to determine the surface  $G$  of the reservoir at 40 meters' depth:

$$G \text{ (at depth 40 m)} = \frac{40}{90} \cdot 40 \cdot 10^3$$

$$= 16.8 \cdot 10^3 \text{ m}^3$$



The volume of the reservoir  $V$  at depth 40 meters is then:

$$V = 1/3 \text{ GL}$$

$$V \text{ (at depth 40 m)} = 1/3 \text{ GL} \cdot 16.8 \cdot 10^3 \cdot 3400$$

$$= 19.1 \cdot 10^6 \text{ m}^3$$

**Table.2 Types of Reservoirs**

Reservoir Type	“M”	Standard Classification
Gorge	1.0-1.5	IV
Hill	1.5-2.5	III
Flood plain-foothill	2.5-3.5	II
Lake	3.5-4.5	I

When the parameter  $M$  is determined, the reservoir type can be determined with the help of Table 7. As can be seen in Figure 26, the parameter  $M$  is assessed on 2.54. This indicates that the reservoir falls under the category of a Floodplain-foothill reservoir type. It also indicates that the reservoir type is very close to the Hill type of reservoir. The boundaries for this type of reservoir are between and 2.5, so this is very close.

**Classify The Mrica Reservoir Based On the Capacity/Inflow Ratio**

The last classification that can decide which reservoir preservation methods can be implemented for the Mrica reservoir is the classification based on the Capacity/ Inflow ratio. The yearly inflow of water from the river has been measured between the years 2010 and 2020. The result is that the average river flow rate was  $2610 \pm 500$  million  $\text{m}^3$  water per year.

With the initial capacity of the reservoir known, the original Capacity/Inflow ratio can be determined as follows:

$$CI = 140 \cdot 10^6 / 2610 \cdot 10^6$$

$$= 0.054$$

**Table.3 Typical Values of Density and Porosity of Various Soils**

Soil description	Density of solids $\rho_s$ [kg/m <sup>3</sup> ]	Density of soil in situ (wet) $\rho_{si}$ [kg/m <sup>3</sup> ]	Porosity $n$ [%]
Silt	2650	1100 – 1400	80 – 90
Loose clay	2650	1400 – 1600	60 – 80
Packed clay	2650	1800 – 2000	35 – 50
Sand with clay	2650	1800 – 2000	40 – 50
Sand	2650	1900 – 2000	35 – 45
Coarse sand with gravel	2650	2050 – 2200	28 – 36
Clay boulders	2650	2320	20





**Table.4 Values for The Calculation of the Necessary Production Weeks**

Parameter	Value	Unit
Type dredger	IHC Beaver 9029C	[-]
Total installed power	13000	[kW]
Diameter pipeline	0.9	[m]
Velocity in pipeline	3.5	[m/s]
Density of in situ soil	1900	[kg/m <sup>3</sup> ]
Density of the water	1000	[kg/m <sup>3</sup> ]
Density of the mixture	1310	[kg/m <sup>3</sup> ]
Operational hours per day	24	[hr/day]
Operational days per week	7	[days/week]
Network efficiency	60.00	[%]
Number of CSD's used	1	[-]

From the production and cost estimating sheet follows that the amount of time that is necessary to remove the yearly sediment inflow in the Mrica Reservoir is 25 weeks. The calculation values of Ciria Dredging Cost Standards are used for the calculation of the weekly production costs. The value for the depreciation and interest and the value for maintenance and repair are found within these costs standards. The total installed power is 13000 kW for the IHC Beaver 9029C. With the price for marine diesel at 1454 \$/ton and the Euro/Dollar rate at 0.764, the weekly costs for fuel and lubricants can be calculated. Extra costs that are made for this project are the costs that are made to transport the material towards the deposit site. For a first estimate it is assumed that the dredged up sediments are transported towards the river downstream of the dam and no storage site is needed. This assumption is valid because the total volume of the dredged up sediment equals the yearly inflow of sediment into the reservoir. The sediment load will be a bit above average because of the smaller time frame, but the extra sediment load will be acceptable. Extra costs that have to be made to construct a storage site are therefore not necessary.

**Table.5 Values for The Calculation of the Necessary Production Weeks**

Parameter	Value	Unit
Type dredger	Backhoe	[-]
Volume excavator bucket	15	[m <sup>3</sup> ]
Amount of bucket delivered per minute	1	[bucket/min]
Operational hours per day	24	[hours]
Operational days per week	7	[days]



Network efficiency	60.00	[%]
Number of excavators used	3	[-]

**Table.6 Values for The Calculation of the Necessary Production Weeks**

Parameter	Value	Unit
Type dredger	IHC Beaver 6518C	[-]
Total installed power	2700	[kW]
Diameter pipeline	0.65	[m]
Velocity in pipeline	3.5	[m/s]
Density of in situ soil	1400	[kg/m3]
Density of the water	1000	[kg/m3]
Density of the mixture	1120	[kg/m3]
Operational hours per day	24	[hr/day]
Operational days per week	7	[days/week]
Network efficiency	60.00	[%]
Number of CSD's used	1	[-]

Other expenses that have to be taken into account, such as the risk and the insurance, are taken as a percentage of the weekly production costs and are calculated by the Excel-sheet. The one-time costs that are considered are rough estimates of what the costs would be in reality. These one-time costs consist of transporting the dredgers and all the material towards the reservoir and the costs that have to be taken into account for the assembly and disassembly. For transport costs 50.000 euro is taken into account, for assembly and disassembly 50.000 euro. This number has to be multiplied by 3, since that is the amount of dredgers that are used. This eventually results in the production of 54.432 m3 per backhoe per week, which means that there are 43 production weeks necessary to remove 7.060.000 m3 of sediment with 3 backhoes. The total weekly production costs are for the 3 backhoes combined 912.413 euro per week and the total one-time costs 300.000 euro. The total costs of using a backhoe in the Mrica Reservoir are 5.63 euro per removed m3 sediment.

The other option of using a mechanical excavator in the Mrica Reservoir is using a grab dredger. As was the case with the use of an excavator on tracks, a grab dredger also has a limited dredging depth. The grab dredger is therefore not capable of reaching till the bottom of the reservoir. The production rate is also lower due to the smaller volume of the bucket, but the operational costs are less expensive. In the case of the Mrica Reservoir, a grab dredger with an installed power of 212 kW is chosen. This type of grab dredger has a grab capacity of 5 m3 and is capable of dredging up to 24 meter. Although this is not the dredging depth that is needed to remove all the sediments from the reservoir, the dredger will still be able to remove most of the settled sediments from the reservoir. This can be verified in the cross section of the Mrica Reservoir in Figure 24. It is assumed that the operational speed of the backhoe allows the dredger to deliver 1 bucket per minute. This can be transformed towards a discharge of sediments per time unit by the Excel-sheet. Operational hours also have to be taken into account in order to calculate the total needed production weeks of an excavator on tracks. A workweek of 24 hours per day and 7 days per week is chosen. A network efficiency of 60 per cent takes into account the time in which the backhoe cannot operate due to moving of the dredger to another location in the reservoir, maintenance, repair or other work troubling issues.

In order to remove the set amount of sediment of 7.060.000 m3, the number of grab dredgers that are used in this particular project is 9. This is the sufficient amount of dredgers for the Mrica Reservoir according to the calculation sheet. An overview of the chosen values for the calculation of the production weeks.



**Table.7 Values for The Weekly Costs Calculation**

Parameter	Value	Unit
Depreciation and interest	6741	[€/week]
Maintenance and repair	4250	[€/week]
Price marine diesel	1454	[\$/ton]
Euro/dollar rate	0.785	[€/€]
Needed amount of extra pontoons	22	[-]
Price per pontoon	3837	[€/week]
Needed amount of tugboats	8	[-]
Price per tugboat	4701	[€/week]
Needed amount of unloading cranes at the shore	2	[-]
Price per unloading crane at the shore	32036	[€/week]
Costs constructing and maintaining and maintaining quay wall	5000	[€/week]
Costs storage site	-	[€/week]

Other expenses that have to be taken into account, such as the risk and the insurance, are taken as a percentage of the weekly production costs and are calculated by the Excel-sheet. The one-time costs that are considered are rough estimates of what the costs would be in reality. These one-time costs consist of transporting the dredgers and all the material towards the reservoir and the costs that have to be taken into account for the assembly and disassembly. For transport costs 50.000 euro is taken into account, for assembly and disassembly 50.000 euro. This number has to be multiplied by 9, since this is the amount of dredgers that will be used. This eventually results in the production of 18.144 m3 per grab dredger per week, which means that there are 43 production weeks necessary to remove 7.060.000 m3 of sediment with 9 backhoes. The total weekly production costs are for the 9 backhoes combined 441.121 euro per week and the total one-time costs 900.000 euro. The total costs of using a backhoe in the Mrica Reservoir are 2.83 euro per removed m3 sediment.

**Conclusion Case Study Mrica Reservoir**

The Mrica Reservoir has severe sedimentation problems within the reservoir. If no effective counter measurements are taken, the reservoir will lose primary functions already in 2020. Hydrodynamic solutions such as flushing and sluicing offer a relative cheap method to remove sediment. However, these methods are not able to cope with the massive yearly sediment load of more than 7 million m3. These solutions can contribute to the sedimentation problem, but do not provide a sustainable solution for the Mrica Reservoir. Therefore, the only long term solution therefore is to remove the sediment by using a mechanical excavator (a grab dredger or an excavator on tracks), a Cutter Suction Dredger or by a Water Injection Dredger. Cost calculation of these methods result in the following diagram.

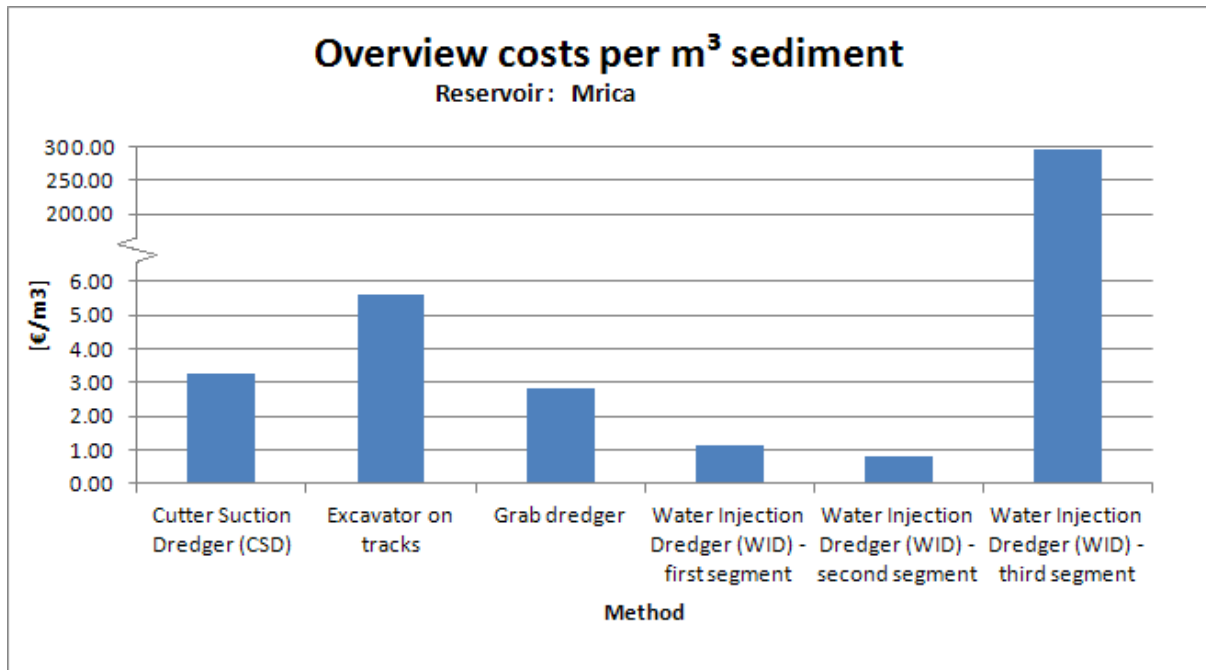


Figure No.4 Overview Costs Per M³ Sediment

3.2 MILLSITE RESERVOIR

Quantify The Sedimentation Problem in The Millsite Reservoir

Classify The Millsite Reservoir Based On The Empirical Area Reduction Method

The first classification method that is applied to the Millsite Reservoir is the Empirical Area- Reduction method. A more detailed explanation of this method. The basic of this method is the shape of the reservoir and the method divides the reservoir into 4 different shapes. The shape is determined by the parameter “M”, which is the reciprocal of the slope of the line obtained by plotting the reservoir depth at the vertical axis against the reservoir capacity at the horizontal axis on log-log paper.

Data from the Utah Department of Environmental Quality- Division of Water Quality provides specifications that are necessary to classify the Millsite Reservoir. For the initial capacity of 22.2 million cubic meters, the reservoir depth is 31 meters. To obtain the second point on the log-log paper, a calculation has to be done, where the reservoir is schematized in the same way as is done in Figure Below. The reservoir length *L* is 2220 meters, so the surface *G* is then:

$$V = 1/3 GL$$

$$22.2 \cdot 10^6 = 1/3 \cdot G \cdot 2220$$

$$G = 30 \cdot 10^3 \text{ m}^2$$

The surface *G* at the maximum depth of 31 meter is then 30·103 m2 and this coincides with the data from the Utah Department of Environmental Quality. They state that the width of the reservoir is 1066 meter, which leads combined with the reservoir depth of 31 meter to a surface *G* of 1066·31 = 33.046 meter. Since the dam is a little bit smaller than the maximum reservoir width (as can be seen in Figure 30), the surface *G* of 30·103 is correct.

To calculate the second point needed for the plot on the log-log paper, a reservoir capacity proportional to a certain reservoir depth has to be determined. The mean reservoir depth is chosen, which corresponds with a reservoir depth of 14 meter. Since a similar surface profile of *G* can be assumed at reservoir depth of 14 meter, *G* can be calculated as follows:

$$(\text{at depth } 14 \text{ m}) = 14/31 \cdot 30 \cdot 10^3$$

$$= 13.5 \cdot 10^3 \text{ m}^2$$

The proportional length of the reservoir can be calculated with the use of similar shapes. The length of the reservoir when the reservoir is at maximum capacity is 2220 meter. The length *L* of the reservoir at depth 14 meter is then:

$$31/14 = 2220/L \text{ (at depth } 14 \text{ m)}$$

$$(\text{at depth } 14 \text{ m}) = 1003 \text{ m}$$

$$V = 1/3 \cdot GL$$



$$V \text{ (at depth 14 m)} = 1/3 \cdot 13.5 \cdot 10^3 \cdot 1003$$

$$= 4.51 \cdot 10^3 \text{ m}^3$$

**Classify The Millsite Reservoir Based On The Capacity/ Inflow Ratio**

The ration between the capacity of the reservoir and the average annual water inflow can now be used to classify the reservoir. The original Capacity/Inflow ratio of the reservoir when the reservoir was just constructed was:

$$C/I = 22.2 \cdot 10^6 / 17.8 \cdot 10^6$$

$$= 1.25 \text{ Year}$$

The current Capacity/Inflow ratio of the Millsite Reservoir is:

$$C/I = 19.0 \cdot 10^6 / 17.8 \cdot 10^6$$

$$= 1.08 \text{ year}$$

**Table.8 Values for The Calculation of the Necessary Production Weeks**

Parameter	Value	Unit
Type dredger	IHC Beaver 6518C	[-]
Total installed power	2700	[kW]
Diameter pipeline	0.65	[m]
Velocity in pipeline	3.5	[m/s]
Density of in situ soil	1400	[kg/m <sup>3</sup> ]
Density of the water	1000	[kg/m <sup>3</sup> ]
Density of the mixture	1120	[kg/m <sup>3</sup> ]
Operational hours per day	24	[hr/day]
Operational days per week	7	[days/week]
Network efficiency	60.00	[%]
Number of CSD's used	1	[-]

From the production end cost estimating sheet follows that the amount of time that is necessary to remove the yearly sediment inflow in the Millsite Reservoir is 1 week. The calculation values of Ciria Dredging Cost Standards<sup>41</sup> are used for the calculation of the weekly production costs. Interpolation of these calculating values from is necessary in order to find the exact value for the depreciation and interest and for the value of maintenance and repair. The power of the cutters motors is 585 kW for a 6518C Cutter Suction Dredger, which results in 44.091 euro per week for depreciation and interest and 31.920 euro per week for maintenance and repair. The total installed power is 2700 kW for the IHC Beaver 8518C. The price for marine diesel is set to 1454 \$/ton<sup>42</sup> and the Euro/Dollar rate at 0.76443. The calculation sheet then calculates the total weekly costs for fuel and lubricants.

**Table.9 Values for The Weekly Costs Calculation**

Parameter	Value	Unit
Depreciation and interest	44091	[€/week]
Maintenance and repair	31920	[€/week]
Price marine diesel	1454	[\$/ton]
Euro/Dollar rate	0.785	[€/€]
Needed amount of booster stations	0	[-]
Price per booster station	-	[€]
Costs of the pipeline, per week		
Length pipeline on shore	300	[m]
Price per meter	0.90	[€/m]
Length floating pipeline	1700	[m]
Price per meter floating pipeline	9.35	[€/m]
Needed amount of bends	5	[€]
Price per bend	16.70	[€]
Maintenance and repair pipeline, percentage of total costs pipeline	0	[%]



One-time costs that have to be considered in this case are costs to construct a storage site, costs to transport the dredger to the reservoir and costs to assemble and disassemble the dredger. A storage site is necessary, since it is not possible to return the dredged up sediment back into the river downstream of the dam due to high sediment peaks. The storage site has to be able to store 97.000 m<sup>3</sup> of sediment, which means that the dimensions of the storage site must be in the order of 180 x 180 x 3 meter. A cove just south-west of the reservoir can be used to construct a relatively cheap storage site, where a levee of 400-meter-long and 3 meters' high is necessary. Assuming that the cubical meter sand necessary per meter levee is in the order of 25 m<sup>3</sup>, the total volume of sand is than 10.000 m<sup>3</sup>. Taken into account a rough estimate that the transport and the treatment of the construction material costs 10 euro per m<sup>3</sup>, results is the estimate that the construction of the deposit site is in the order of 100.000 euro. For transport costs and costs to assemble and disassemble the dredger is 200.000 euro, respectively 150.000 euro taken into account.

**Table.10 Values for The Calculation of the Necessary Production Weeks for an Excavator On Tracks**

Parameter	Value	Unit
Type dredger	Backhoe	[-]
Total installed power	1600	[kW]
Volume excavator bucket	15	[m <sup>3</sup> ]
Amount of bucket delivered per minute	1	[bucket/min]
Operational hours per day	24	[hours]
Operational days per week	7	[days]
Net -work efficiency	60.00	[%]
Number of excavators used	1	[-]

**Table.11 Values for The Weekly Costs Calculation of an Excavator On Tracks**

Parameter	Value	Unit
Depreciation and interest	105112	[€/week]
Maintenance and repair	45080	[€/week]
Price marine diesel	1454	[\$/ton]
Euro/Dollar rate	0.785	[€/€]
Needed amount of extra pontoons	3	[-]
Price per pontoon	3837	[€/week]
Needed amount of tugboats	1	[-]
Price per tugboat	4701	[€/week]
Needed amount of unloading cranes at the shore	1	[-]
Price per unloading crane at the shore	32036	[€/week]
Costs constructing and maintaining and maintaining quay wall	5000	[€/week]

Other expenses that have to be taken into account are taken as a percentage of the weekly production costs and are calculated automatically by the Excel-sheet. Rough estimates are made for the one-time costs that are considered. The costs for the construction of a storage site are similar to the costs of the storage site treated in the previous paragraph: 100.000 euro. For transport costs 50.000 euro is taken into account, for assembly and disassembly costs 50.000 euro. This results in the total costs of 769.929 euro for using an excavator on tracks in the Millsite reservoir in order to remove the yearly inflow of sediment, which is equal to 7.94 euro per removed m<sup>3</sup> sediment. This is quite high since the size of the mechanical excavator is considerable in order to reach the required depth of the reservoir.

**Table.12 Values for The Weekly Costs Calculation of a Grab Dredger**

Parameter	Value	Unit
Depreciation and interest	6741	[€/week]
Maintenance and repair	4250	[€/week]
Price marine diesel	1454	[\$/ton]
Euro/Dollar rate	0.785	[€/€]
Needed amount of extra pontoons	3	[-]



Price per pontoon	3837	[€/week]
Needed amount of tugboats	1	[-]
Price per tugboat	4701	[€/week]
Needed amount of unloading cranes at the shore	1	[-]
Price per unloading crane at the shore	32036	[€/week]
Costs constructing and maintaining and maintaining quay wall	5000	[€/week]

The construction of a storage site is estimated to be 100.000 euro, as was considered with the case of an excavator on tracks. The transport and assembly/disassembly costs are lower however, since the used equipment is much smaller. This is estimated to be 25.000 euro each. This results in the total costs of using a grab dredger in the Millsite Reservoir of 627.691 euro. Divide this by the amount of sediment that is going to be removed, then the unit costs of this method are 6.47 euro per m<sup>3</sup> sediment removed. Also in this case has to be remarked that the sediment still has to be removed from the deposit site. This will increase the costs of using a grab dredger considerably.

**Conclusion Case Study Millsite Reservoir**

To investigate whether or not Water Injection Dredging is a cost efficient method to preserve the capacity in reservoirs, a smaller reservoir than the earlier discussed Mrica Reservoir is investigated. This way, a sensitivity analyses can be made to investigate the influence of the size of the sedimentation problem to the Water Injection Dredging method. Some of the possible methods require a permanent installation. To make these methods comparable with the other ones, these installations are considered to operate for 30 years and a 1/30 part of the capital costs is added to the yearly costs. It results in the following overview.

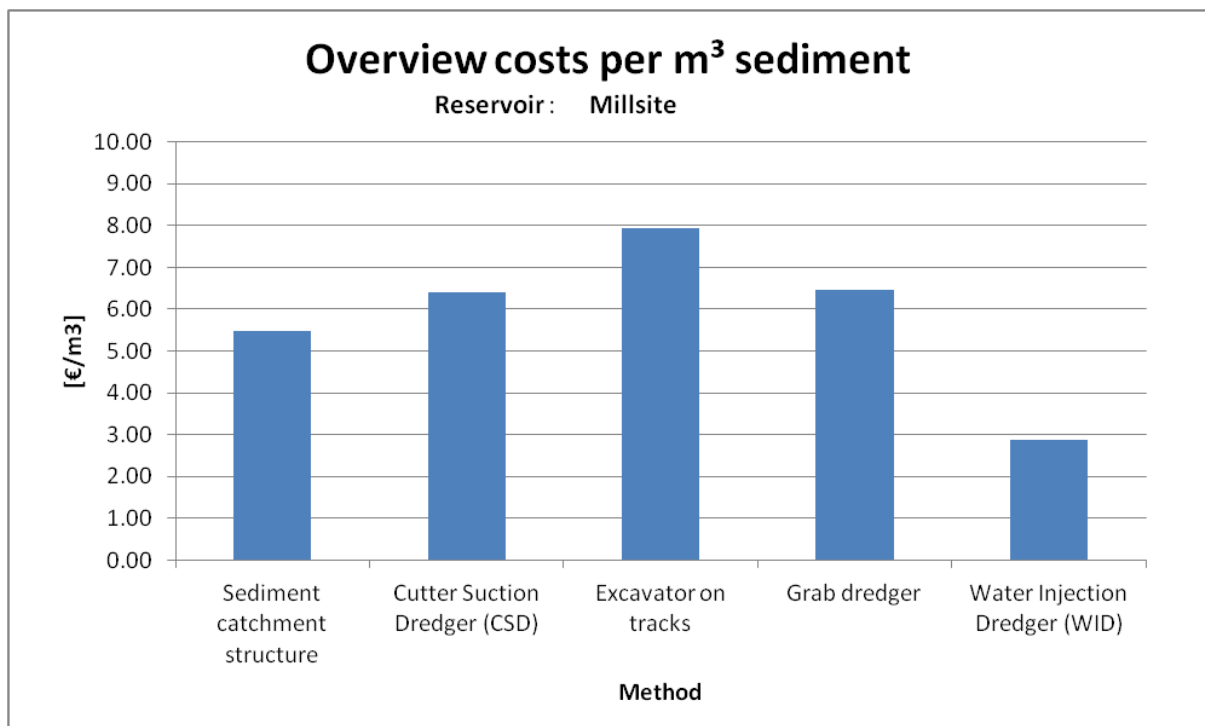
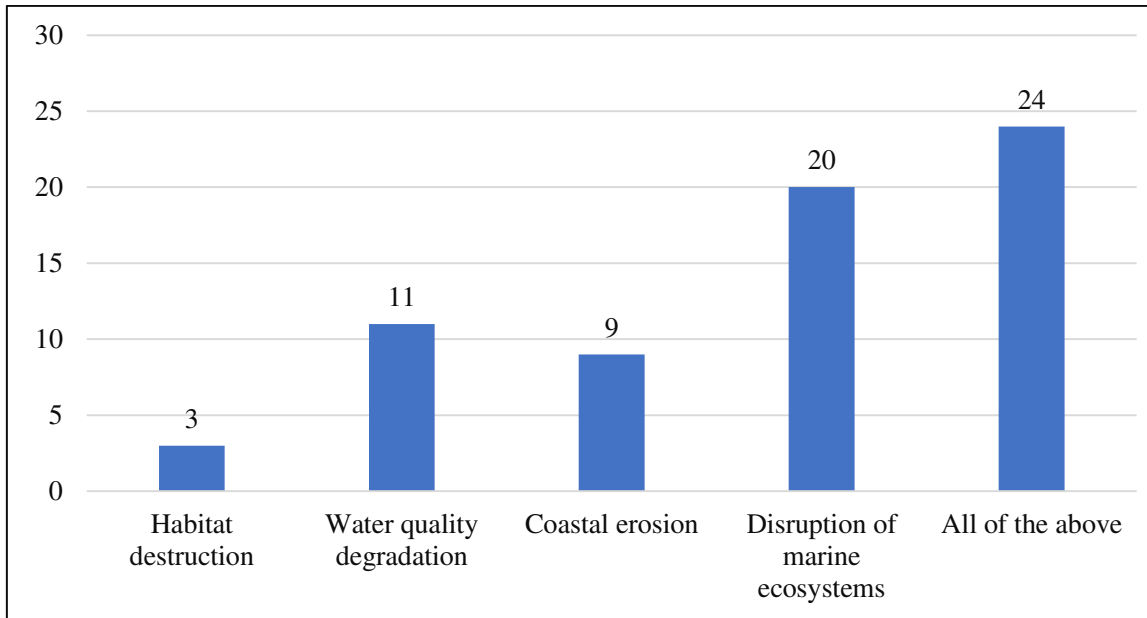


Figure No.5 Overview Costs Per M<sup>3</sup> Sediment Within the Millsite Reservoir



**Data Analysis**

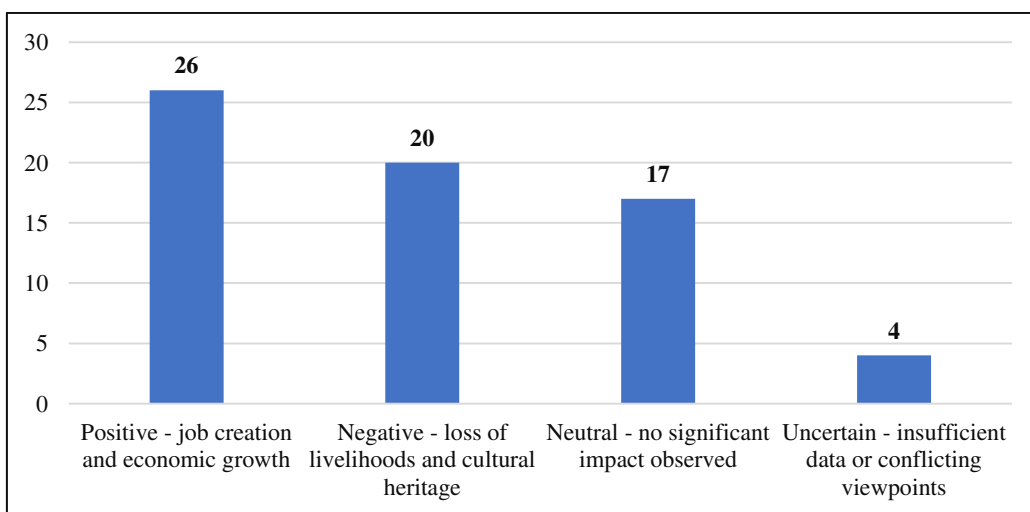
**Primary environmental impacts associated with sand dredging activities in Maharashtra**



**Figure No.6 Primary environmental impacts associated with sand dredging activities in Maharashtra**

The table outlines primary environmental impacts linked to sand dredging activities in Maharashtra, India. Among the listed impacts, disruption of marine ecosystems emerges as the most significant concern, accounting for nearly 30% of reported instances. Water quality degradation and coastal erosion follow closely behind, representing 16.4% and 13.4% of occurrences, respectively. Habitat destruction is noted in 4.5% of cases. Interestingly, a substantial portion, 35.8%, encompasses all listed impacts, suggesting a comprehensive and interconnected environmental challenge. These findings underscore the multifaceted nature of sand dredging's ecological repercussions, emphasizing the need for holistic mitigation strategies to address its diverse environmental effects effectively.

**The social and economic impacts of sand dredging in Maharashtra**



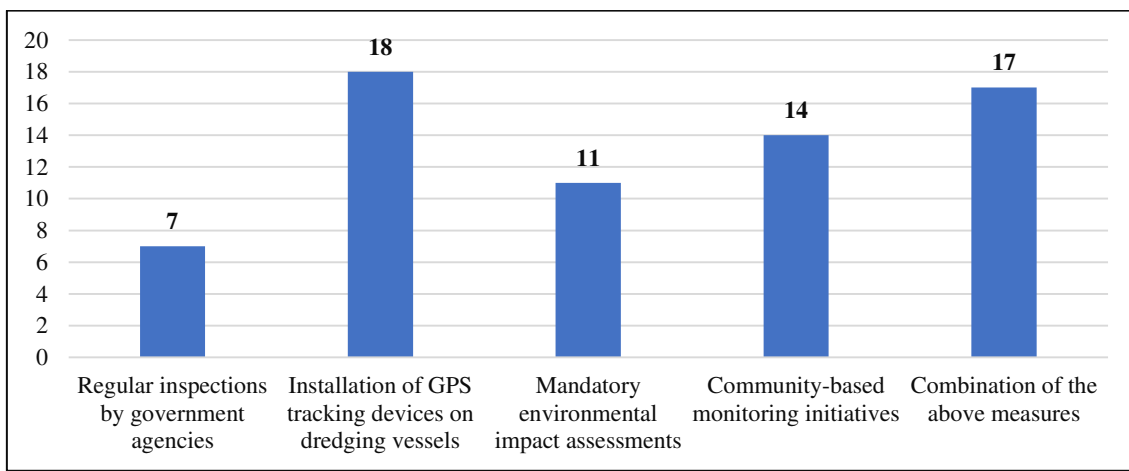
**Figure No.7 The social and economic impacts of sand dredging in Maharashtra**





The table presents insights into the social and economic repercussions of sand dredging in Maharashtra. It delineates that 38.8% of respondents perceive positive outcomes, emphasizing job creation and economic expansion. Conversely, 29.9% express concerns about negative ramifications, citing the loss of livelihoods and erosion of cultural heritage. Meanwhile, 25.4% report a neutral stance, indicating no discernible impact. However, a noteworthy 6% find themselves uncertain due to insufficient data or conflicting viewpoints. This distribution suggests a complex landscape where the benefits of economic growth are weighed against cultural and livelihood losses, with a significant portion of stakeholders still seeking clarity on the issue.

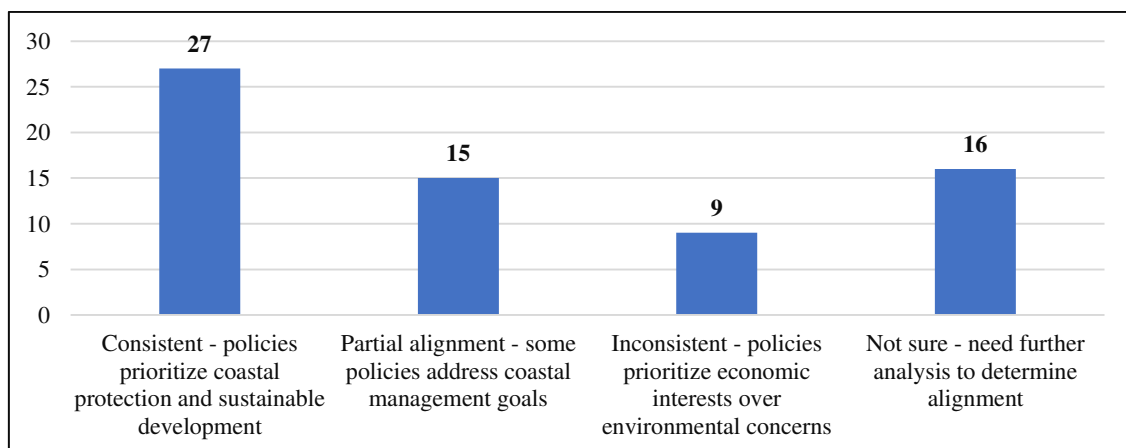
**Current sand dredging regulation in Maharashtra**



**Figure No.8 Current sand dredging regulation in Maharashtra**

The table illustrates the current sand dredging regulations in Maharashtra. Approximately 10.4% of regulations involve regular inspections by government agencies, while 26.9% mandate the installation of GPS tracking devices on dredging vessels. Around 16.4% require mandatory environmental impact assessments, and 20.9% emphasize community-based monitoring initiatives. Furthermore, 25.4% of regulations consist of a combination of the aforementioned measures. These findings suggest a multi-faceted approach to managing sand dredging activities, incorporating various levels of oversight, environmental assessment, and community involvement to ensure sustainable and responsible practices.

**Sand dredging policies in Maharashtra align with broader coastal zone management**



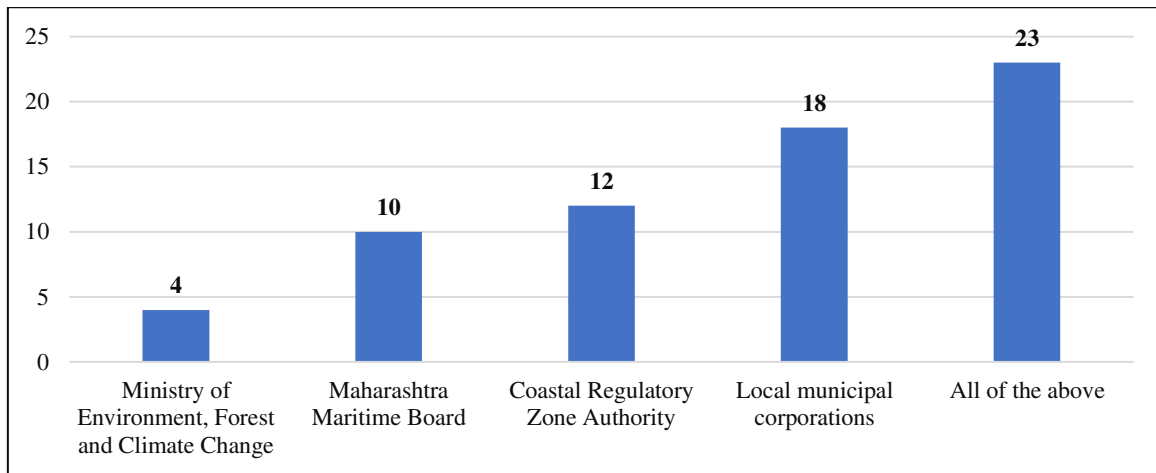
**Figure No.9 Sand dredging policies in Maharashtra align with broader coastal zone management**

The table illustrates the alignment between sand dredging policies in Maharashtra and broader coastal zone management objectives. Approximately 40.3% of policies consistently prioritize coastal protection and sustainable



development. Around 22.4% exhibit partial alignment, addressing some coastal management goals. Conversely, 13.4% prioritize economic interests over environmental concerns, indicating inconsistency. About 23.9% of policies require further analysis to determine their alignment status. Overall, the data suggests a mixed landscape of policy approaches, with a significant portion emphasizing environmental sustainability but also notable instances of prioritizing economic gains over ecological preservation.

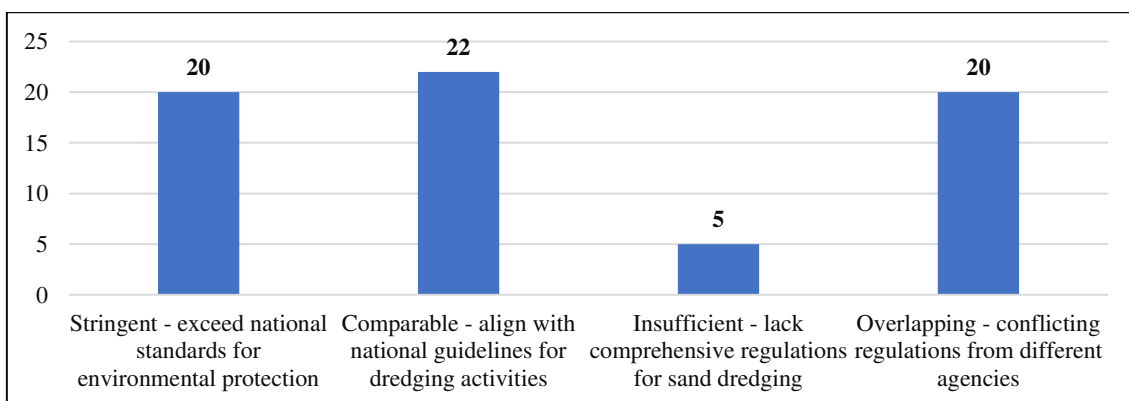
**Table 6.5 Maharashtra government agencies monitor sand dredging**



**Figure No.10 Maharashtra government agencies monitor sand dredging**

The table illustrates the distribution of responsibility among Maharashtra government agencies for monitoring sand dredging activities. The Ministry of Environment, Forest and Climate Change oversees this practice in 6% of cases, followed by the Maharashtra Maritime Board at 14.9%, and the Coastal Regulatory Zone Authority at 17.9%. Local municipal corporations carry out monitoring in 26.9% of instances. Interestingly, 34.3% of cases involve all of the mentioned agencies collectively. This data suggests a shared accountability approach towards regulating sand dredging, emphasizing collaborative efforts among multiple governmental bodies to ensure effective oversight and management of this environmentally sensitive activity in Maharashtra.

**Assess sand dredging regulations: Maharashtra vs. national.**



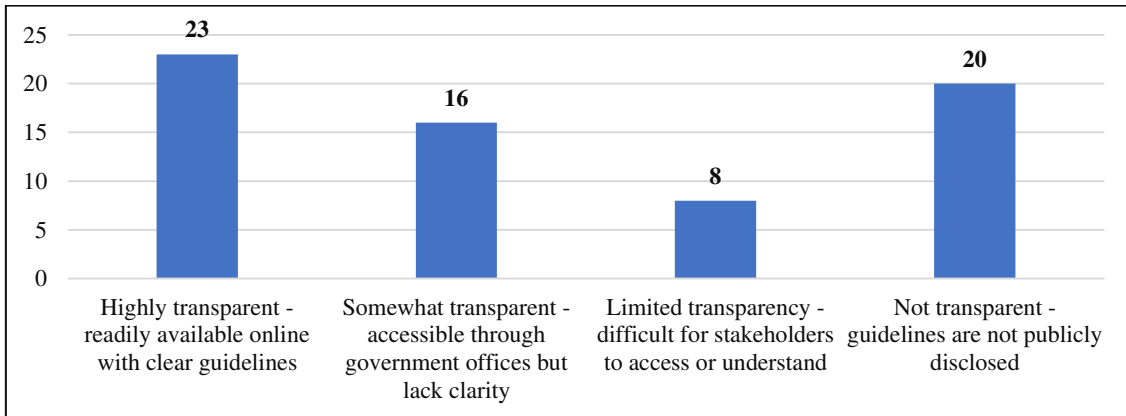
**Figure No.11 Assess sand dredging regulations: Maharashtra vs. national.**

The table illustrates a comparison between sand dredging regulations in Maharashtra and the national standards, based on frequency and percentage distribution. Among the findings, 29.9% of the regulations in Maharashtra are considered more stringent than the national standards for environmental protection. A comparable percentage, 32.8%, indicates alignment with national guidelines for dredging activities. However, concerns arise with 7.5% showing insufficient



regulations, indicating a lack of comprehensive measures in Maharashtra. Another 29.9% highlights overlapping regulations, signifying conflicts stemming from different agencies. This analysis emphasizes the need for cohesive, well-defined regulations to ensure effective environmental protection and sustainable sand dredging practices in Maharashtra.

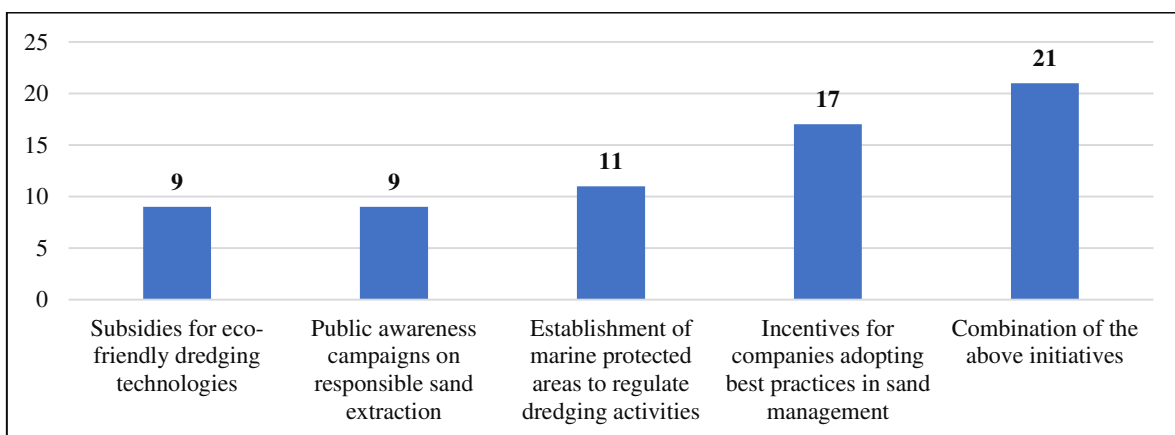
**Government sand dredging guidelines: accessible, transparency**



**Figure No.12 Government sand dredging guidelines: accessible, transparency**

The table illustrates the accessibility and transparency levels of government sand dredging guidelines. Notably, 34.3% of the guidelines are highly transparent, easily accessible online with clear directives. However, 23.9% are somewhat transparent, available through government offices but lacking clarity. Additionally, 11.9% exhibit limited transparency, posing challenges for stakeholders to access or comprehend. Alarming, nearly 30% of the guidelines are not transparent, with no public disclosure. This suggests a significant gap in information dissemination, hindering stakeholder involvement and potentially leading to environmental or regulatory issues. Addressing this disparity is crucial for fostering accountability and ensuring sustainable sand dredging practices.

**Government initiatives for sustainable sand dredging**



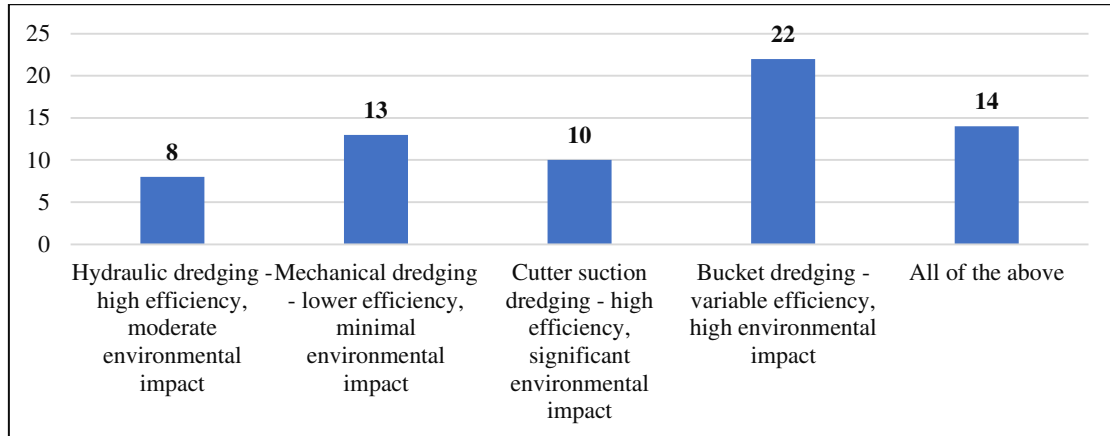
**Figure No.13 Government initiatives for sustainable sand dredging**

The table illustrates government initiatives aimed at promoting sustainable sand dredging practices. Notably, the establishment of marine protected areas to regulate dredging activities received the highest frequency (16.4%), highlighting the emphasis on environmental conservation. Incentives for companies adopting best practices in sand management closely follow, indicating a significant effort to incentivize responsible behavior within the industry (25.4%). Moreover, a combination of these initiatives (31.3%) showcases a holistic approach towards sustainability. Additionally, subsidies for eco-friendly dredging technologies and public awareness campaigns both contribute equally



(13.4%), underlining the importance of technological innovation and community engagement in achieving sustainable sand extraction.

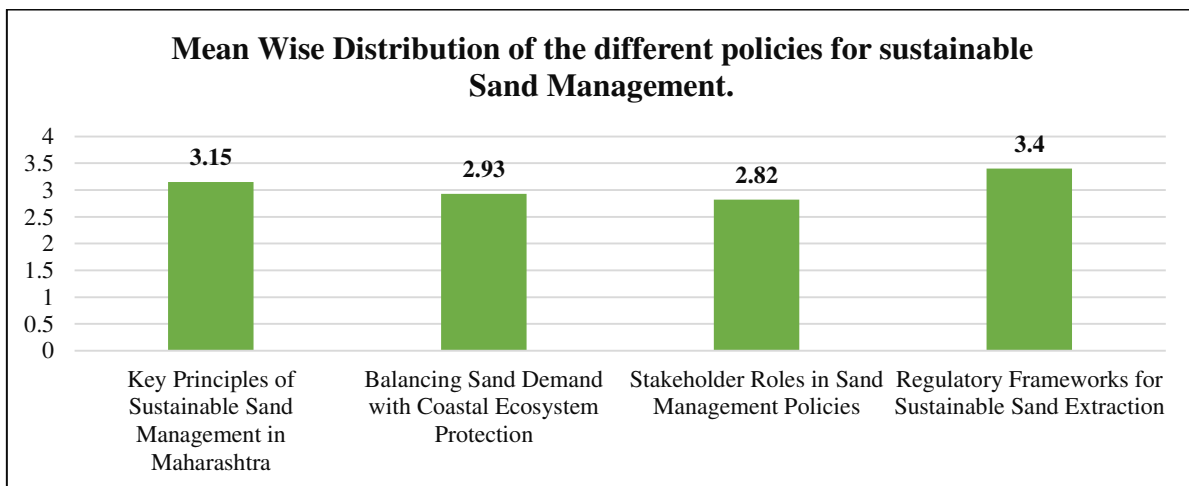
**Sand dredging techniques: efficiency and environmental impact.**



**Figure No.14 Sand dredging techniques: efficiency and environmental impact.**

The table illustrates various sand dredging techniques categorized by their efficiency and environmental impact. Hydraulic dredging, known for high efficiency with moderate environmental impact, is chosen 11.9% of the time. Mechanical dredging, offering lower efficiency but minimal environmental impact, is preferred by 19.4%. Cutter suction dredging, characterized by high efficiency yet significant environmental impact, is used 14.9% of instances. Bucket dredging, with variable efficiency and high environmental impact, is the most frequently employed at 32.8%. A minor proportion, 20.9%, opt for a combination of all techniques.

**Mean Wise Distribution of the different policies for sustainable Sand Management.**



**Figure No.15 Mean Wise Distribution of the different policies for sustainable Sand Management.**

The table presents the mean and standard deviation for various policies aimed at sustainable sand management in Maharashtra. "Key Principles of Sustainable Sand Management" received the highest mean score of 3.15, indicating it's perceived as relatively effective and well-established. "Balancing Sand Demand with Coastal Ecosystem Protection" and "Regulatory Frameworks for Sustainable Sand Extraction" follow closely behind, suggesting moderate effectiveness. However, "Stakeholder Roles in Sand Management Policies" scored lower at 2.82, indicating a perceived



need for improvement or clarity in stakeholder engagement strategies. The standard deviations suggest varying levels of dispersion or agreement among respondents regarding the effectiveness of these policies.

**Table.13 Impact Factor of Sand Dredging and management of dredged material**

Sand Dredging and management of dredged material			
	Reliability	P Value	Impact Factor from Mean Values
Assessment of the Impact of Sand Dredging Policies	0.878	0.000	3.39
Existing Government Guidelines and Initiatives	0.789	0.000	2.98
Different types of dredging and their use	0.765	0.000	3.12
Different policies for sustainable Sand Management	0.823	0.000	3.29

The table presents an assessment of various aspects related to sand dredging and the management of dredged material, focusing on reliability, p-values, and impact factors derived from mean values. Firstly, it indicates a high level of reliability across all categories, with values ranging from 0.765 to 0.878, suggesting robustness in the methodologies employed for assessment. The low p-values of 0.000 suggest statistical significance in the findings, indicating strong evidence to reject the null hypothesis. The impact factor from mean values ranges from 2.98 to 3.39, indicating the perceived influence or importance of each aspect within the topic. Assessing the impact of sand dredging policies seems to have the highest impact factor, followed closely by different policies for sustainable sand management, with scores of 3.39 and 3.29 respectively. Existing government guidelines and initiatives and different types of dredging and their use also hold significant impact factors of 2.98 and 3.12 respectively. Overall, the table highlights the importance of comprehensive policies and initiatives in sand dredging and the management of dredged material, suggesting that effective management strategies are crucial for sustainable environmental practices in this domain.

**Comparative analysis of Methods for Sand dredging**

In this section conventional sand dredging is compared with current sand dredging with preventive measures techniques using MSP

Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt.	Cost/Use	Accrue	Base	Code	Add N
1 Total station	Work		T		100%	₹ 500.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
2 Poklen	Work		P		100%	₹ 1,000.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
3 Tractor	Work		T		100%	₹ 500.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
4 Labour	Work		L		100%	₹ 40.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
5 Engineer	Work		E		100%	₹ 1,200.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
6 Project Manager	Work		P		100%	₹ 500.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
7 JCB	Work		J		100%	₹ 1,000.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
8 Compactor	Work		C		100%	₹ 938.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
9 Hyva	Material		H			₹ 150,000.00		₹ 0.00	Prorated			
10 Dredger	Work		D		100%	₹ 400.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		
11 Compactor	Work		C		100%	₹ 300.00/hr	₹ 0.00/hr	₹ 0.00	Prorated	Standard		

**Resource sheet**

The provided tabular data outlines the resources utilized within a project management context, delineating their associated rates, characteristics, and billing methods. Among the resources listed, various work-related assets such as Total station, Poklen, Tractor, Labour, Engineer, Project Manager, JCB, Compactor, and Dredger are identified alongside the material resource Hyva. Each resource is assigned a shorthand code for reference purposes. Availability percentages are provided, indicating the utilization rate of each work-related resource, all of which are denoted at 100%, signifying full utilization when engaged in the project. The rates associated with each resource are specified, with work-related resources being charged per hour (e.g., ₹ 500.00/hr for Total station) and material resources being



billed as lump sums (e.g., ₹ 150,000.00 for Hyva). Additionally, the table outlines the billing method for each resource, with options including Prorated or Standard. Notably, overtime rates are listed as zero for all resources. This comprehensive breakdown of resources, rates, and billing methods serves as a foundational reference for project planning, budget allocation, and resource management endeavors.

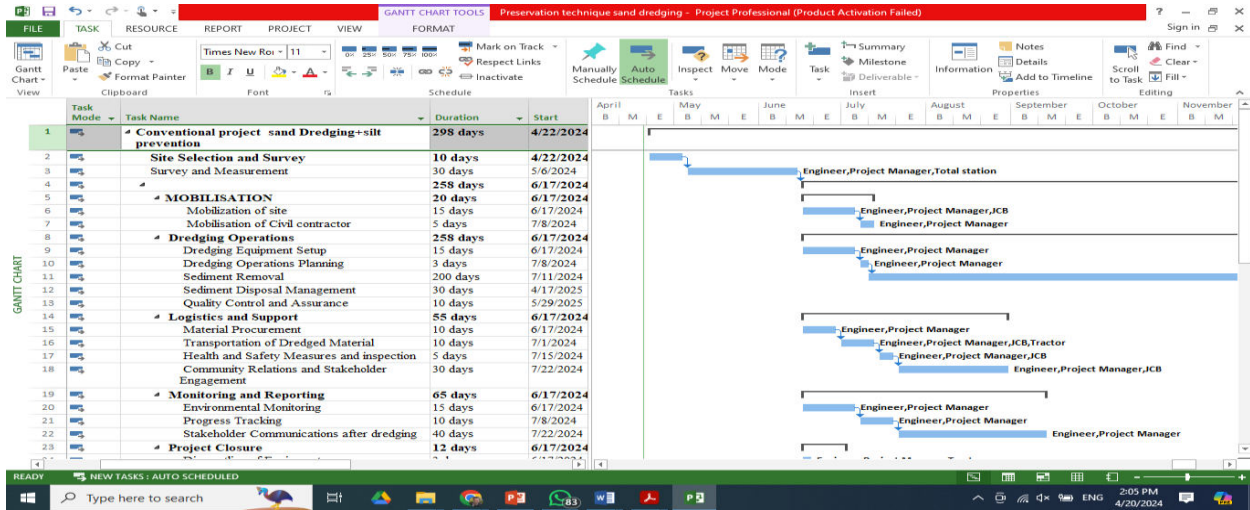


Figure No.16 Conventional project sand Dredging silt prevention

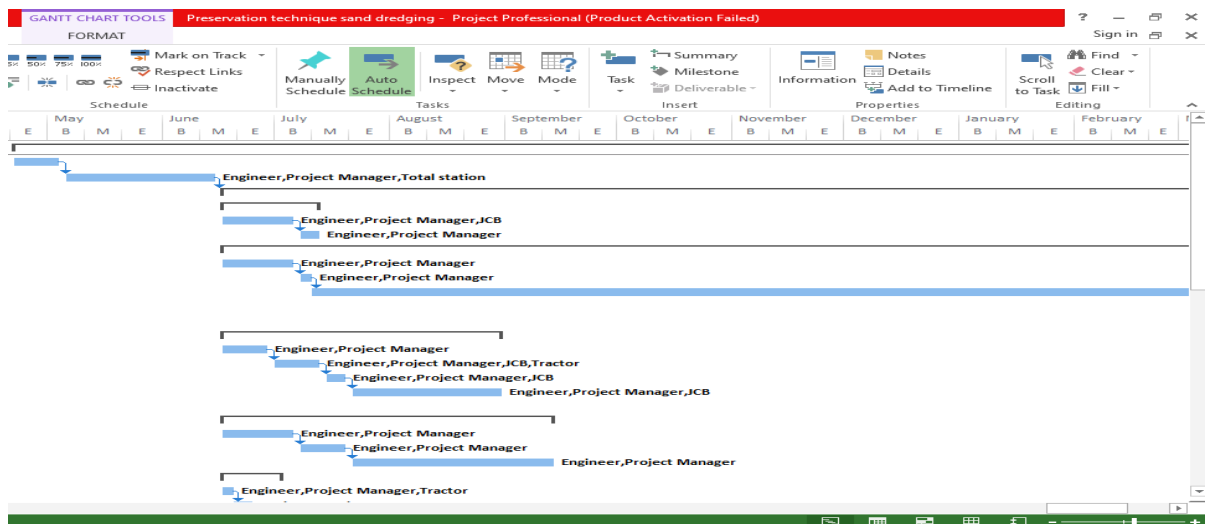
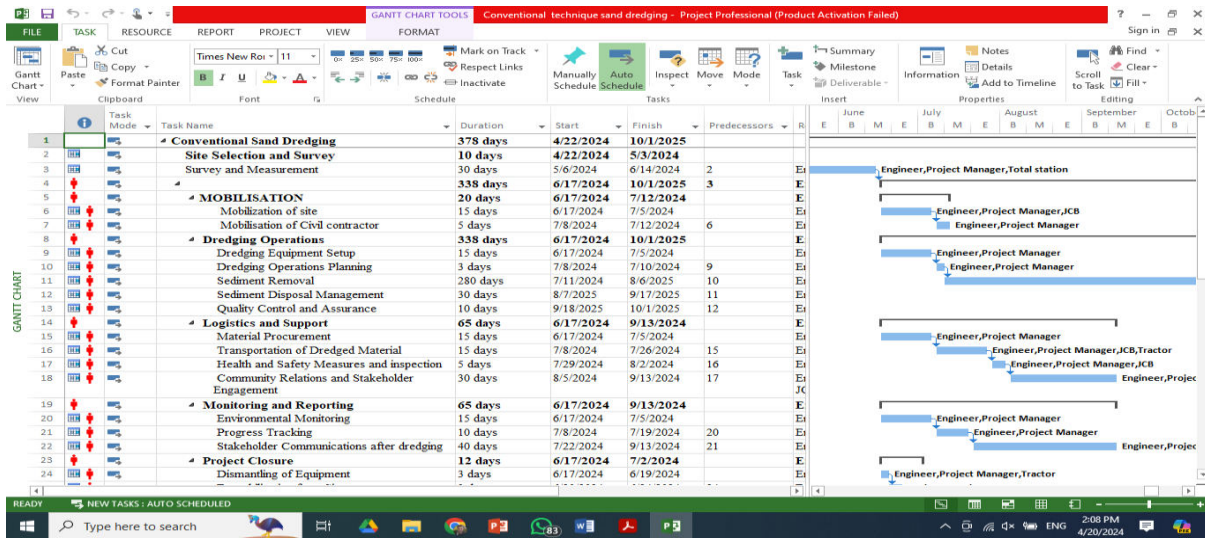
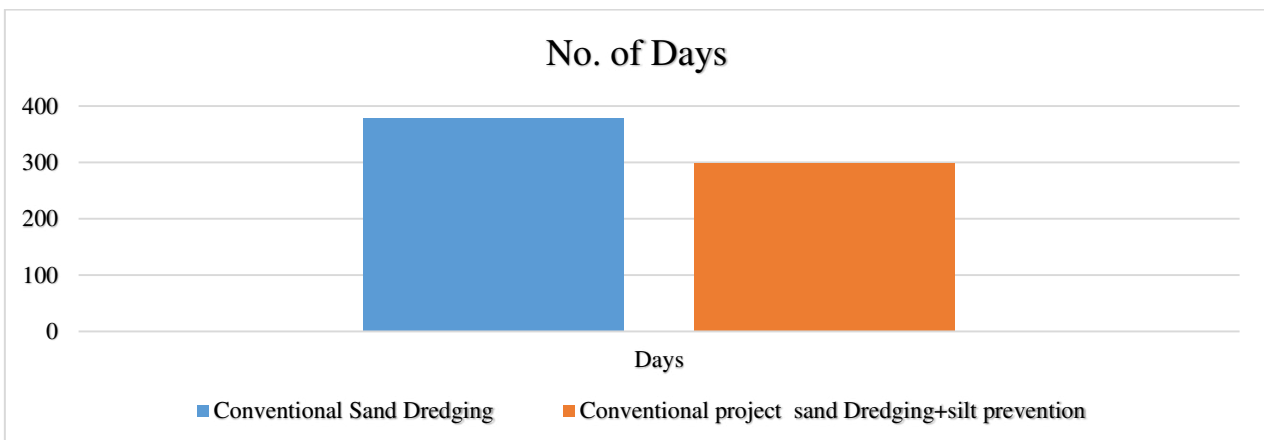


Figure No.17 Gantt Chart Conventional project sand Dredging + silt prevention



### Conventional Sand Dredging

The provided MSP (Microsoft Project) program outlines a comprehensive schedule for a sand dredging project with silt prevention technique, detailing various tasks and their respective durations. Total duration of project as per schedule is 298 days which can be reduced by 80 days as compared to Conventional dredging method. Beginning with project initiation and site preparation, activities such as site selection, survey, and mobilization are scheduled to commence on specific dates, ensuring a systematic start to the project. Subsequently, dredging operations are meticulously planned, encompassing equipment setup, operational planning, and the critical task of sediment removal, spanning a significant duration to accommodate the complexity of the task. Logistics and support activities, including material procurement, transportation, and safety measures, are strategically integrated to facilitate seamless project execution. Monitoring and reporting components are embedded throughout the project lifecycle, incorporating environmental monitoring, progress tracking, and stakeholder communications to ensure transparency and accountability. As the project approaches its conclusion, efforts are dedicated to project closure tasks such as dismantling equipment, demobilization, environmental assessment, and documentation, ensuring a methodical and thorough wrap-up of project activities. Additionally, the preservation of silt is addressed with detailed tasks focusing on research, selection of techniques, implementation, and quality control measures, underscoring the project's commitment to environmental stewardship. Overall, the MSP program provides a structured roadmap for project management, enabling effective planning, coordination, and execution of tasks essential for the successful completion of the sand dredging project.



#### IV. CONCLUSION

In this study sand dredging techniques and silt prevention techniques are studied in details total two case studies and 67 responses are taken for this work in which spss data analysis and MSP planning is done. In finding it's observed that total execution days in terms of activities are reduced to 37% using silt prevention method. The management of sedimentation in reservoirs is critical to ensure the long-term functionality and efficiency of dams. Research highlights the necessity of addressing sedimentation issues proactively, even during the initial dam design phase, to minimize costly countermeasures required later. Empirical formulas like those developed by Brune, Brown, and Churchill offer preliminary insights into sedimentation rates, aiding in the classification of reservoirs for targeted preservation strategies. Among sediment removal techniques, Water Injection Dredging emerges as a promising solution due to its efficiency and cost-effectiveness. However, its success hinges on specific reservoir conditions and sediment characteristics. Challenges such as downstream sediment impact and accumulation near the dam necessitate careful planning and engineering assessments. Cost estimations based on case studies, like those of the Mrica and Millsite Reservoirs, showcase Water Injection Dredging's potential in managing significant sediment loads. For large reservoirs, constructing dedicated Water Injection Dredgers could optimize sediment removal operations, minimizing dependence on external contractors and adapting dredging strategies to seasonal water levels. Additionally, combining Water Injection Dredging with other methods like Mechanical Excavation or Cutter Suction Dredging can enhance overall effectiveness. Implementing Water Injection Dredging requires a comprehensive, long-term dredging strategy tailored to each reservoir's unique conditions. Leveraging natural water discharges during rainy seasons for sediment transport can optimize efficiency while minimizing water loss. Moreover, empowering dam operators with their own dredging equipment offers flexibility and control over sediment management timelines, ensuring timely responses to changing reservoir conditions. In conclusion, proactive sediment management strategies, anchored by techniques like Water Injection Dredging, are essential for sustaining reservoir functionality and mitigating the adverse effects of sediment accumulation. Customized, adaptive approaches must be adopted, considering reservoir size, sediment characteristics, and operational flexibility to optimize cost-efficiency and long-term reservoir preservation.

#### REFERENCES

1. F. Onorati, C. Mugnai, M. Pulcini, and M. Gabellini, "A framework for the integrated assessment and management of dredged materials in Italy: A case study based on the application of Local Sediment Quality Guidelines," *J. Soils Sediments*, vol. 13, no. 2, pp. 474–487, 2013, doi: 10.1007/s11368-012-0636-4.
2. A. L. Pena, M. V. A. Martins, P. Miranda, D. L. Terroso, and F. Rocha, "Sediments Quality and Potential Uses of Dredged Material: a Case Study (Portugal)," *J. Sediment. Environ.*, vol. 2, no. 2, 2017, doi: 10.12957/jse.2017.29215.
3. C. Sheehan and J. Harrington, "Management of dredge material in the Republic of Ireland - A review," *Waste Manag.*, vol. 32, no. 5, pp. 1031–1044, 2012, doi: 10.1016/j.wasman.2011.11.014.
4. [4] P. Solanki, B. Jain, X. Hu, and G. Sancheti, "A Review of Beneficial Use and Management of Dredged Material," *Waste*, vol. 1, no. 3, pp. 815–840, 2023, doi: 10.3390/waste1030048.
5. Z. A. Collier, M. E. Bates, M. D. Wood, and I. Linkov, "Stakeholder engagement in dredged material management decisions," *Sci. Total Environ.*, vol. 496, pp. 248–256, 2014, doi: 10.1016/j.scitotenv.2014.07.044.
6. M. Motiur Rahman and M. Shahjahan Ali, "Dredging and Dredged Material Management: a Case Study of Mongla Port," no. February, pp. 1–10, 2020.
7. M. Bahgat, "Optimum use of dredged materials for sustainable shoreline management in Nile Delta," *Water Sci.*, vol. 32, no. 1, pp. 115–128, 2018, doi: 10.1016/j.wsj.2017.12.001.
8. R. Duszyński, A. Duszyńska, and S. Cantré, "New Experiences in Dike Construction with Soil-Ash Composites and Fine-Grained Dredged Materials," *Stud. Geotech. Mech.*, vol. 39, no. 4, pp. 17–24, 2017, doi: 10.1515/sgem-2017-0033.
9. G. Cevikbilen, B. Teymur, U. Karadogan, H. M. Basar, S. Dağlı, and L. Tolun, "An Investigation on Suitability of Dredge Materials on Road Construction," *ICOCEE*, vol. 11, no.4 June 2020, pp. 1–7, 2015.
10. C. K. M. Katherine E. Brutsche, Brian C. McFall, Honghai Li, Jesse E. McNinch, Jase D. Ousley, Jason A. Engle, "Strategic nearshore placement of dredged sediment at Vilano Beach, Florida," *Shore and Beach*, vol. 85, no. 3, pp. 77–84, 2017.
11. K. E. BRUTSCHÉ *et al.*, "Strategic Placement of Dredged Material in Vilano Beach, Florida, Usa," no. June, pp. 2793–2804, 2019, doi: 10.1142/9789811204487\_0239.





12. P. Ozer-Erdogan, H. M. Basar, I. Erden, and L. Tolun, “Beneficial use of marine dredged materials as a fine aggregate in ready-mixed concrete: Turkey example,” *Constr. Build. Mater.*, vol. 124, No.8 pp. 690–704, 2016, doi: 10.1016/j.conbuildmat.2016.07.144.
13. O. Frihy, W. Moufaddal, E. Deabes, and E. E. D. Helmy, “Economic evaluation of using marine dredged material for erosion control along the northeast coast of the Nile Delta, Egypt,” *Arab. J. Geosci.*, vol. 9, no. 14, 2016, doi: 10.1007/s12517-016-2660-y.
14. V. Kapsimalis *et al.*, “A screening procedure for selecting the most suitable dredged material placement site at the sea. The case of the South Euboean Gulf, Greece,” *Environ. Monit. Assess.*, vol. 185, no. 12, pp. 10049–10072, 2013, doi: 10.1007/s10661-013-3312-2.



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