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1 **Use of Multi-Criterial Involvement Processes (MIP) to Enhance Transparency and**
2 **Stakeholder Participation at Bergen Harbour, Norway**

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1   **ABSTRACT**

2   Use of participatory stakeholder engagement processes could be important to reduce the risk

3   of potential conflicts in managing contaminated sites. Most stakeholder engagement tech-

4   niques are qualitative in nature and require experienced facilitators. This study proposes a

5   multi-criterial involvement process (MIP) to enhance transparency and stakeholder participa-

6   tion and applies it to a contaminated sediment management case study for Bergen Harbor,

7   Norway. The suggested MIP builds on the quantitative principles of MCDA, and also incor-

8   porates group interaction and learning through qualitative participatory methods. Three dif-

9   ferent advisory groups consisting of local residents, local stakeholders and non-resident sedi-

10   ment experts were invited to participate in a stakeholder engagement process to provide con-

11   sensual comparative advice on sediment remediation alternatives. For stakeholders or resi-

12   dents to be able to embrace a complex decision such as selection of remediation alternatives,

13   the involvement process with lateral learning, combined with MCDA giving structure, ro-

14   bustness and transparent documentation was preferable. Additionally, MIP results in consis-

15   tent ranking of remediation alternatives across residents, stakeholder and experts, relative to

16   individual intuitive ranking without MIP.

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18   KEYWORDS: Stakeholder involvement, contaminated sediment management, multi-criteria

19   decision analysis, citizens' jury

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1   **INTRODUCTION**

2   Emerging environmental challenges coupled with increased stakeholder awareness

3   and concerns call for more effective stakeholder involvement processes for environmental

4   management. A structured stakeholder involvement process could help in overcoming disa-

5   greements and result in better management alternatives (Slob et al., 2008). Examples of qua-

6   litative involvement processes include focus groups with facilitated communication between

7   parties to reach consensus (Kitzinger, 1995). Co-operative discourse methods are also de-

8   scribed by Renn (1999) involving establishment of development criteria and alternatives us-

9   ing value trees elicited by stakeholders and experts in round table meetings. Group Delphi is

10   another systematic, interactive forecasting method which relies on a panel reaching consensus

11   through sequential use of questionnaire and intermittent discussions.

12   Multi-criteria decision analysis (MCDA) has been proposed as a method to enhance

13   stakeholder involvement in sediment management and to facilitate decision making of com-

14   plex problems (Kim et al., 2010; Linkov et al., 2005; Yatsalo et al., 2007). The purpose of

15   MCDA in these studies has been to support evaluation and selection among management al-

16   ternatives in an interactive process involving, decision makers, stakeholders, scientists. Me-

17   thodologically, MCDA requires developing hierarchy of criteria and metrics to compare man-

18   agement alternatives and subsequent elicitation of weights to quantify relative importance of

19   criteria as well as scoring of alternative performance based on these criteria. The MCDA ap-

20   proach overcomes the limitations of unstructured individual and group decision-making by

21   providing decision transparency and focusing discussion on assessing the weights and scores.

22   Thus MCDA may be valuable in quantitative decision making; however, focus on participato-

23   ry aspects in the involvement processes for sediment management is also warranted

24   (Sparrevik et al., 2010).

1   In order to enhance the value of participatory stakeholder involvement in environmen-

2   tal management we propose a multi-criterial involvement process (MIP) which builds on the

3   quantitative principles of MCDA, and also incorporates group interaction and learning

4   through qualitative participatory methods. The process bears resemblance to earlier proposed

5   MCDA processes for sediment management (Alvarez-Guerra et al., 2010; Oen et al., 2010;

6   Kiker et al., 2005; Hong et al., 2010). However, this process also addresses recruitment and

7   includes an involvement and learning step inspired by deliberative decision making using

8   citizens juries (Soma, 2010; Smith & Wales, 2000). The application of the MIP is illustrated

9   using sediment remediation alternatives for Bergen harbour in Norway as well as conducting

10   the MCDA for three different advisory groups including local residents, local stakeholder and

11   non-resident sediment experts. A comparison of individual versus group consensus-based

12   ranking of alternatives is also presented.

13   **THE MULTI-CRITERIAL INVOLVMENT PROCESS (MIP)**

14   *Stakeholder Involvement in Contaminated Site Management*

15   A project execution process for managing contaminated sediments typically proceeds

16   through specific project phases involving different actors in the process, Figure 1. Problem

17   owners are usually active in the *problem formulation* and the *approval* phase where the se-

18   lected concept is being approved by regulatory authorities (Oen et al., 2010). Consultants are

19   normally active in the *concept evaluation* phase collecting lines of evidence and evaluating

20   different concepts of remedial solution based on these data (Sparrevik & Breedveld, 2010).

21   This often also includes preparing permit applications or environmental impact assessments

22   (EIA). A simplified linear process is illustrated in Figure 1; however, in reality the process

23   may be highly iterative with several decision processes conducted in parallel.

1   Stakeholders, here defined as people, organisations or groups who are affected by the

2   issue and who have the power to make, support or oppose the decision (Susskind et al., 1999)

3   tend normally to be involved late in the process, often prior to the *decision* making as a part of

4   formal hearings. Individuals in their capacity as concerned residents are often not at all in-

5   volved in the formal decision process insofar as they are not directly affected by project im-

6   pacts and therefore not active in the formal hearings. The proposed remedial solution circu-

7   lated for hearing is often designed based on technical feasibility, budget, time and political

8   perspective. The manoeuvring space for changes at this stage of a project is often limited,

9   which may cause problem owners to defend the solution instead of allowing a constructive

10   stakeholder dialogue (Kasperson & Kasperson, 2005). This unfortunate situation may lead to

11   significant opposition that could lead to increased costs and delays in the execution phase of

12   contaminated site remediation projects (Sparrevik et al., 2010).

13   *Description of the MIP Methodology*

14   The MIP methodology as shown in Figure 2 uses multi-criteria decision analysis and consen-

15   sus-based deliberation to structure the involvement process;

16   <u>Objectives and alternatives</u>

17   The 1st step of the process includes formulation of the project objectives, selection of alterna-

18   tives and study recruitment methods. The problem owner responsible for the decision is pre-

19   sumed to be highly active in this phase. The 2nd step consists of recruitment of the advisory

20   group. Depending on the project objectives defined in previous step, inhabitants representing

21   public interests or stakeholders representing specific business interests may be recruited. The

22   method used to recruit participants is important with regards to representation of different

23   standing/values in relation to the project impacts. The project team (including researchers or

24   consultants) is recommended to be responsible for this step.

1   Criteria metrics

2   The 3rd step consists of identification of criteria. The project team is assumed to be heavily

3   involved in this step, possibly in cooperation with the problem owner. In the 4th step, im-

4   pacts/scores for each criterion are assessed (based on available technical information and ex-

5   pert judgment). We recommend that the project team carry out this task, since it requires de-

6   tailed technical knowledge about the alternative performances for selected criteria.

7   Measuring performance

8   The intention of the 5th step is to allow the advisory group to discuss the analysis with the

9   project team and invite experts with specialized expertise to clarify questions. The advisory

10   group should also evaluate and alter the criteria earlier proposed if necessary. The 6th step

11   includes criteria weighting.

12   Information synthesis

13   In the 7th step data are processed by the project team and results are presented to the advisory

14   group. In the 8th and last step, the advice from the project is presented to the problem owner.

15   **MIP APPLICATION TO THE BERGEN HARBOUR SEDIMENT REMEDIATION**

16   **STUDY**

17   *Objectives, Alternatives and Methods*

18   Bergen harbour study objectives

19   The harbor area of Bergen is contaminated due to previous industrial activities such as

20   naval shipyards and manufacturing industries, earlier releases of municipal sewerage and ur-

21   ban run-off from diffuse sources. One of the major contributors to harbor contamination is

22   polychlorinated biphenyls (PCBs), originating from paint on house facades (Jartun et al.,

23   2008). The area is 1 of 17 fjords in Norway prioritized for remedial actions by the Norwegian

1   Government (MD, 2006; MD, 2002). The area also has a dietary advisory for fish consump-

2   tion based on PCB and mercury concentrations in fish. The work with contaminated sediment

3   management has been progressing for several years focusing on site investigations, risk as-

4   sessments and preparations of management plans. At present, complementary archeological

5   investigations, as well as plans for field trial experiments to assess remediation methods are

6   being executed. The objectives with the MIP in this case was to provide valuable advice to the

7   problem owner on how advisory groups perceive hypothetical remediation alternatives distill-

8   ed from the recommendations laid out in the management plans.

9   Remediation alternatives

10   Five alternatives for remediation of the contaminated sediments in Bergen harbor were

11   suggested on as an outcome from the discussions with the problem owner. Alternative 1 con-

12   stitutes natural recovery. The sources of contamination in Bergen have significantly decreased

13   due to reduced industrial activity, better emission control and waste water treatment. It is es-

14   timated that background values for contaminant fluxes to the water from the sediments will be

15   reached within a time span of 50 years due to natural deposition of clean sediments on top of

16   the contaminated sediments (FM, 2005). Alternative 2 consists of an active reduction of the

17   contaminant flux by capping a 1.5 km^2 area in the inner fjord basin with a 30 cm layer of

18   clean material, as indicated in Figure 3. Capping has proven to be efficient to reduce contami-

19   nant transport from contaminated sites (Eek et al., 2008) but since it reduces sailing depth, it

20   may have practical limitations (Palermo, 1998). A combined alternative was therefore formu-

21   lated consisting of capping the majority of the area, combining with dredging areas with the

22   highest concentration of PCB (hot-spot areas) and areas where sailing depth could be an issue,

23   Figure 3. This alternative was then divided into 3 sub-alternatives based on the handling of

24   the dredged material. In alternative 3, near shore disposal facilities were assumed to be con-

25   structed with the possibility to reclaim land for property development, whereas alternative 4

1   and 5 consisted of land disposal in local and national waste disposal facilities respectively.

2   The transport distances to disposal was 1 km (near shore disposal), 12 km (local disposal) and

3   800 km (national disposal site) respectively.

4   *Recruitment of Advisory Group*

5   The MIP process requires involvement of advisory groups in the management process.

6   Three advisory groups were created in this case: local residents, local stakeholders, and non-

7   resident sediment experts as summarised in Table 1.

8   *The local residents* were randomly recruited based on the census lists in order to

9   represent the general community interest in Bergen. The local residents were asked to act both

10   in their capacity as individuals, promoting the private values of their household, and also as

11   community representatives in a citizens' jury setting (Soma and Vatn 2010) promoting values

12   representing the community needs. The local residents were selected to have fair gender and

13   age representation and cover residential location in the immediate vicinity and at a distance

14   (>3 km) from the Bergen harbor area. None of the persons recruited had previously been di-

15   rectly involved in contaminated sediment management. In total 20 participants were invited to

16   participate in 3 sessions where of 17 (85%) participated in all sessions. At the last meeting, 4

17   residents' panel groups (5 participants in each group) were established for consensus-based

18   deliberative evaluation.

19   *The local stakeholder group* was recruited to reflect specific interests in the Bergen

20   harbor remediation case; based on a review of available documents, commentaries to the pre-

21   pared management plan, media interest and correspondence with the problem owner. In total,

22   103 potentially interested parties for the group were identified. From this list, a subset of 14

23   stakeholders were selected based on mapping in an influence-interest grid (Chinyio &

24   Olomolaiye, 2010). *Influence* was defined as the potential to affect the process either through

1   formal legislative rights or by informal mobilisation through media and financial instruments.

2   *Interest* was defined as the potential level of benefits or losses the stakeholder could experi-

3   ence from the process. Like influence, interest was categorized into formal interests such as

4   regulatory issues and informal interests such as gain or loss of image and popularity. Discus-

5   sions with 2 of the selected stakeholders and the problem owner were conducted, and as a

6   result from these discussions the list was expanded from 14 to 23. These individuals were

7   invited to participate in advisory meetings, but also to potentially function as an advisory

8   group in forthcoming project stages in Bergen harbour. 16 people out of the 23 agreed to par-

9   ticipate in a stakeholder group and 11 people (48%) participated in the advisory meetings.

10   *The non-resident sediment experts* were scientists / consultants and regulators working

11   with contaminated sediments on a daily basis. The experts were recruited from the Oslo area

12   without particular connections to Bergen. One session with 4 participants was organised with

13   non-project researchers from one of the participating institutes in the study; a separate session

14   with 8 participants (19 invited) was conducted using web based recruitment specifically tar-

15   geting consultants, researchers and regulators working with contaminated sediments in the

16   Oslo region.

17   *Selecting Weighing Method and Identification of Criteria*

18   Evaluation of different MCDA weighing methods for use in sediment management

19   has been investigated earlier and all methods have strengths and weaknesses. The selection of

20   appropriate methods will then be a choice between the accuracy of the utility or value based

21   methods, the user friendliness of the AHP method or the simplicity of the outranking methods

22   (Linkov et al., 2007). The use of MCDA with an advisory group early in the project process

23   places the onus on finding methods that are simple and user friendly. Later stages of using

24   MCDA for decision making should emphasis consistency and robustness as well. The AHP

25   method (Saaty, 1987), was selected for this study based on its advantages in scoring and user

1   friendliness. AHP completely aggregates the decision problem into a single objective function

2   and uses a compensatory optimization approach. AHP uses a quantitative comparison method

3   that is based on pair-wise comparisons of decision criteria, rather than utility and weighting

4   functions.

5   The pair-wise comparison may be performed on different levels in a decision tree al-

6   lowing people to compare criteria in pairs avoiding cognitively more challenging multiple

7   simultaneous comparisons. In this study a hierarchical decision tree was used, organizing cri-

8   teria in 3 levels reflecting the different pillars of sustainable development; environmental,

9   societal and economical aspects (UN, 1987). Under each criterion, sub-criteria were added.

10 The advisory groups were able to discuss and comment on the criteria, but only a limited

11 number of alterations were performed in order to assure consistency between the groups.

12 *Assessing Criteria Weights*

13   Criteria weights to each criterion were set based on the EIA as presented in the man-

14 agement plan for the harbor (FM, 2005) and consultations with sediment experts. The criteria

15 and the criteria weights are provided in Table 2 and are briefly described below;

16 Environmental criteria

17   The environmental risk was expressed as reduction in flux of PCB from the contami-

18 nated sediments, compared to today's baseline scenario. It was assumed that both capping and

19 dredging will be very efficient in reducing the flux of contaminants from the sediments. The

20 effect of dredging is slightly lower due to re-sedimentation of dredged material on top of the

21 dredged seabed after the operation (FM, 2005).

22   The reduction in human health was assessed based on 10% exceedance of the maxi-

23 mum tolerable risk (MTR) (Baars, 2001), compared to the percent exceedance calculated for

24 the current situation. The calculation of MTR is mainly based on consumption of fish which is

1   exposed to contaminated sediments and to some degree from direct exposure to water and

2   sediment during bathing. The calculation is based on a fish consumption of 15 meals pr month

3   from the contaminated area, which is conservative, since no participants indicated that they

4   had consumed fish from the harbor area during the past year.

5   Greenhouse gas house emissions were calculated based on the vessel transport dis-

6   tances from shore to capping area for alternatives 2-5, also including the distances from the

7   dredging area to shore and lorry transport to disposal sites for alternatives 3-5. Emission data

8   from Statistics Norway (www.ssb.no) was used for the calculations. In order to illustrate the

9   magnitude of emission values to the advisory group participants, the figures were normalized

10   against emissions from the estimated yearly emission from a private car (1530 kg CO_2-eq,

11   www.naturvern.no).

12   Societal criteria

13   The construction impact was assessed as an ordinal number proportional to the surface

14   area impacted during remediation. It was also assumed that capping would be both faster and

15   cause less need to reorganize maritime activities in the area than dredging.

16   The disposal location was also addressed as an ordinal number where a local solution

17   was considered more favorable than using a national disposal site. This is based on an as-

18   sumption that sediment storage is best handled by local solutions (Breedveld, 2007). The cri-

19   teria was also used to investigate whether disposal solutions close to residential areas were

20   disfavoured (NIMBY-effects) (Dyer & Sarin, 1982).

21   The wharf area, Bryggen, is defined as a world heritage site on the UNESCO list

22   (whc.unesco.org) and thus was an important aspect to be addressed in the MCDA. It was as-

23   sumed that all marine operations will negatively affect the preservation of marine cultural

24   heritage for the future, with dredging resulting in more negative impact than capping.

1   The possibility of land reclamation is only relevant for the dredging and near seashore

2   alternative where it was assumed that construction of a confined disposal will establish land

3   for property development. The area of reclaimed land was used as the criteria weight.

4   Economic criteria

5   Economic criteria were developed to observe how the distribution of cost, local (mu-

6   nicipal financing) and national (governmental financing) were evaluated by the advisory

7   groups. It was assumed that government would finance 25% of the cost for all alternatives and

8   the remaining costs would be shared by local enterprises and the municipality. It was further

9   assumed that enterprises would partially finance the dredging operation, since they would

10   benefit from port development. Initially, private household financing through municipal taxa-

11   tion was addressed in the MCDA. However this criterion turned out to be problematic for the

12   non-resident expert group and was not used for data evaluation.

13   *Involvement and Learning*

14   Three meetings were conducted with the residents and the stakeholders, whereas non-

15   resident experts were invited to 1 session only. The involvement and learning step began in

16   the 1st meeting and included familiarization, general discussions about the study and contami-

17   nated sediments and distribution of written material including description of the MCDA me-

18   thod, remediation alternatives and how the consequence criteria weights were estimated. The

19   non-resident expert group received this information by e-mail. The content of the documents

20   was explained in the 2nd meeting (1st meeting for experts) and sufficient time was allowed for

21   questions and comments. Based on the presented material and their interest, the residents and

22   stakeholder groups themselves requested expert witnesses to clarify and address specific top-

23   ics related to the issue. The intention was to introduce a deliberative discussion valuable to

1   both the advisory groups and the expert witnesses (Renn, 2006) using an approach base on

2   citizens' jury methodology (Soma and Vatn 2010).

3   *Weighing of criteria*

4   Participants were asked to score the consequence criteria weights using questionnaires

5   and were asked to weigh the criteria and adjacent sub criteria in pairs. The scoring was per-

6   formed in the meeting for the resident and stakeholder groups, whereas the experts were

7   asked to perform a preliminary scoring via e-mail before the meeting. Based on earlier expe-

8   rience (Soma, 2010), the original 9 value scale (Saaty, 1987) was replaced with a less com-

9   prehensive scale. We used in total 3 values guided by the text "strong weight" to emphasize

10   high relative importance of the criteria and "neutral weight" to emphasize equal weighing. For

11   participants not answering the question or marking all alternatives, the neutral score was used

12   in the data presentation step. In this study participants were also asked to perform an intuitive

13   ranking of the alternatives directly.

14   *Data Presentation and Discussion*

15   The software DEFINITE (Janssen R & Herwijnen MV., 2007) was used to process the

16   data. For the residents, the results of the MCDA based on individual weighting of criteria

17   were presented and discussed in the group as a whole, before they were divided into residents'

18   panels. Results of individual versus residents' panel based weighting were then compared and

19   discussed. The stakeholders performed their scoring in the last meeting and thus were not pre-

20   sented to the group in the meeting, due to lack of time. The experts where presented prelimi-

21   nary results from the scoring performed before the meeting, but they were allowed to change

22   the scoring based on information given in the meeting. In all cases, the final weighting results

23   were used for ranking the results presented in this study.

24

1   *Evaluation of advice*

2   Representatives from the residents' panels were invited to present their recommenda-

3   tions to the problem owner in a separate meeting. During the stakeholder meetings, the prob-

4   lem owner was actually present. This local stakeholder group is continuing to follow the

5   process in Bergen with regular meetings, allowing them to contribute to on-going discussions

6   about sediment remediation in the harbor.

7   **RESULTS AND DISCUSSION**

8   *Results from the MCDA*

9   The descriptive statistics for the groups show only significant variance between the

10   groups with respect to years of residence in Bergen, Table 1. This was intentional since this

11   group was recruited from persons not living in the Bergen area. The stakeholder group had

12   mostly male participants, whereas the households/residents group was recruited to achieve a

13   balanced male/female representation. It is especially interesting to observe that the differences

14   in initial risk perceptive values relating to contaminated sediments are not significantly differ-

15   ent between the groups. Since experiential beliefs also may influence the analytical outcome

16   of a decision (Slovic et al., 2004) sharing the same initial beliefs about the subject may facili-

17   tate unbiased advice.

18   Table 3 shows the results from the scoring of sediment remediation alternatives. The

19   results have first been calculated individually for each participant and subsequently integrated

20   to mean values for each advisory group as illustrated in the table. A grand mean has also been

21   calculated summarizing results from all groups. In addition, the results from a hypothetical

22   scenario with equal score on all weights are presented to illustrate the influence of weighing

23   on the results. Table 3 illustrates that the MCDA results center on alternatives 2 and 3. A t-

24   test shows that the difference between alternative 1 ($t=-17.3$; $df=3$; $p<0.05$), 4 ($t=-5.5$; $df=3$;

1   p<0.05) and 5 (t=-5.5; df=3; p<0.05) against the grand mean of alternative 3 is significant.

2   The difference between alternative 2 and 3 is non-significant (t=-0.5; df=3; p=0.63). It is also

3   clear that the advisory group weighing has significantly affected the results compared to a

4   hypothetical scenario with equal scores which results in a preference of natural recovery.

5   Additional information may be extracted from the MCDA by analyzing how partici-

6   pants score the criteria using centered weight analysis (Tervonen et al., 2009). This method

7   normalizes each criteria against a scenario where all criteria score equal. In this case a posi-

8   tive value indicates that participants weigh this criterion higher than average and a negative

9   value indicates that the criterion is weighted less than average. As seen in Figure 4, the aver-

10   aged criteria weights are higher than normal for the reduction in human and environmental

11   risk. This observation could explain the low score on a natural recovery scenario, since this

12   alternative has lower weights for the reduction in human and environmental risk than the oth-

13   er remediation alternatives.

14   In addition to mean values, standard deviation is also presented in the figure 4. An

15   analysis of variance (ANOVA) concludes that there exists a significant difference between

16   advisory groups for 2 of the scored criteria, construction impacts and marine archaeological

17   preservation. This indicates that for these criteria the differences between groups are signifi-

18   cantly larger, than the variance within the group. Stakeholders are significantly more con-

19   cerned by construction impacts (F=6.0; df=3; p<0.05), than the other groups. This is natural

20   since this group includes representatives from organisations with close ties to Bergen harbour

21   such as harbour authorities, boat owner associations, etc. For marine archaeological preserva-

22   tion (F=3.9; df=3; p<=0.05), stakeholders are again significantly more occupied with the sub-

23   ject than the non-resident sediment experts. It is also interesting to observe that when the resi-

24   dents respond as individuals they are less occupied with marine archaeological preservation,

25   than when they act on behalf of the community in a residents' panel. This finding is consistent

1   with social science theory and the beliefs in differences between individual normative and

2   social normative values. Soma & Vatn (2010) also observed this phenomena where a delib-

3   erative citizen jury panel setting favoured mobilisation of social values in decision-making,

4   rather than individual values.

5   A histogram of the inconsistency scores for the weighing of criteria is presented in

6   Figure **5**. Normally a value below 0.1 is considered to be a consistent scoring (Saaty &

7   Vargas, 1984). The figure shows that 43 out of 120 frequencies of inconsistency scores are

8   below 0.1 with a mean value of 0.22. However, higher values and outliers are observed, indi-

9   cating inconsistent scoring for some participants.

10   In general, statistical analysis of MCA weighting is expected to show high variances

11   as the method is designed for decision-makers representing broader interests. Large standard

12   deviation in some cases may also be explained by participants giving inconsistent weights, as

13   documented by some of the high inconsistency scores.

14   *Comparing MCDA to intuitive ranking*

15   Table 4 summarizes the number of participants that indicate a specific remediation al-

16   ternative as their preferred alternative either through MCDA or via intuitive ranking. The re-

17   sults given in Table 4 indicate that both methods suggest that alternative 2 and 3 are the most

18   preferred. It is also clear that while the intuitive ranking shows that some of the participants

19   also select other alternatives as their preferential choice, the MCDA clearly deselects these

20   other alternatives as preferential.

21   Figure 6 illustrates the standard deviation between intuitive ranking and MCDA. This

22   comparison provides valuable information regarding the robustness of the process. The results

23   show that in most cases, the standard deviation using MCDA is lower compared to intuitive

24   ranking.

1   *Use of Results for Management Advice*

2   Although the MCDA and the intuitive ranking result in the same most preferred re-

3   mediation alternatives for all groups with alternative 2 (capping) and alternative 3 (capping

4   combined with near shore disposal) being the overall most preferred, the MCDA is more

5   equipped to sort out the "worst alternatives" than intuitive ranking. This potential use of

6   MCDA has also been documented in earlier studies (Linkov et al., 2007). In addition, the use

7   of MCDA in this study also results in lower standard deviation compared to intuitive ranking,

8   which also is in line with findings in earlier studies (Linkov et al., 2009). For the residents

9   group, the lower variance may also be a result of the deliberative consensus based weighting

10   in the residents' panels, relative to individual based non-deliberative weighting.

11   The centered weight analysis of the scoring responses indicates a strong focus on hu-

12   man and environmental risk reduction. The standard deviation presented in figure 4 is in some

13   cases relatively high, which usually is problematic for interpretation of results. In this case it

14   may however be a valuable piece of information, since it may indicate potential disagreement

15   and therefore should be specifically addressed in the management process.

16   *MIP Methodology Evaluations*

17   <u>The role of MCDA in the process</u>

18   One may argue that some of the data obtained through the structured involvement process

19   with MCDA may be obtained by other less resource intensive survey based methods. Wil-

20   lingness to pay studies have previously been used to map preferences and to map household

21   and recreational users willingness to pay for sediment remediation in Norway (Barton et al.,

22   2010). The advantage of such a large sample survey based approach is representation of pub-

23   lic opinion about a project – a typically neglected interest in impact evaluation. Stated prefe-

24   rence survey based valuation methods are also the only valuation methods that address so-

1   called non-use and existence values. However, the contingent valuation method has been

2   questioned regarding inflated willingness-to-pay for contingent on hypothetical project alter-

3   natives, versus actual willingness to pay once real alternatives are on the table. In Norway,

4   low sample response rates have also been shown to affect representativeness of the affected

5   population (Barton et al., 2010). Choice experiment surveys (CE), another stated preference

6   survey-based method, have been proposed as an alternative with cost-saving, small-sample

7   and preference elicitation advantages over contingent valuation (Bateman et al., 2002). CE

8   can be used as a formal approach to 'map' stakeholder's individual preferences for remedia-

9   tion alternatives. However, a condition for using survey-based valuation methods is that the

10 choice of sediment remediation alternatives can be described in terms of their component

11 attributes in a survey setting. The experiences from our study question this possibility, since a

12 highly interactive process seemed to be necessary for participants to be able to understand the

13 relationship between alternatives and their impact criteria, and then to weight alternatives.

14 However, survey-based studies may have a role to play in confirming preferences for a small

15 set of specific project design criteria, once e.g. MCDA has narrowed alternatives and identi-

16 fied contentious criteria; for example willingness to accept reduced accessibility to certain

17 beach locations during a remediation period. For stakeholders or residents to be able to em-

18 brace a complex decision such as selection of remediation alternatives, an involvement

19 process with lateral learning, combined with MCDA giving structure, robustness and transpa-

20 rent documentation is preferable and certainly a necessary step before conducting stated pre-

21 ference survey's to evaluate the representativeness of stakeholder preferences in the popula-

22 tion.

23 Use of AHP as weighing method

24 One of the main advantages using a compensatory weighing approach as AHP is the pair-wise

25 weighing. This builds on the assumption that decision makers are more relaxed with making

1   relative comparisons between the objectives than to score in absolute values (Baron, 1997).

2   This assumption is to a large degree supported by this study. Even though, especially local

3   stakeholders and non-resident experts criticized the choice of criteria and related weights, the

4   majority of the participants were able to perform the weighing with logical results. This indi-

5   cates that AHP is a suitable method for performing MCDA in advisory settings. It is however

6   important to note that use of compensatory methods also has disadvantages to outranking me-

7   thods. The standardization of the utility function is one obvious challenge. In this study, as in

8   many studies, the standardization of the criteria weights was assumed to be linear for all crite-

9   ria. According to prospect theory, this is not correct (Kahneman & Tversky, 1979). This

10   theory argues that the value curve is asymmetrical to the reference point, i.e. people generally

11   put more emphasis on "losses" than on "gains". Thus the asymmetrical value curve is steepest

12   at the reference point subsequently over-emphasizing small losses compared to larger losses.

13   In our case this means that criteria involving negative aspects, such as human and environ-

14   mental risk, should be standardized differently to gains, such as land reclamation, Figure 4.

15   This standardization requires a reweighting of impact scores. In our methodology, the impact

16   assessment scoring document was explained to the groups, and despite substantial simplifica-

17   tion, 2 rounds of expert witnesses were required to clarify its complexities for the residents'

18   panel. In our opinion, further reweighting of impacts based on assumptions about individual's

19   aversion to risk would probably have confused rather than clarified understanding of the EIA

20   information used in the MCA. We therefore elected to disregard more advanced impact scor-

21   ing methods. Another challenge with the AHP weighing approach is the hierarchical structure,

22   since uneven distribution of sub-criteria between the main criteria will "dilute" the importance

23   of the sub-criteria in groups having a greater number of criteria. In outranking methods these

24   issues are not present. Therefore outranking methods may be the preferable choice for deci-

25   sion making where simplicity and robustness is favored to user friendliness in criteria weigh-

1   ing. Use of outranking also allows application of stochastic multi-criteria acceptability analy-

2   sis (SMAA) to the results. In this method, criteria weights may be entered as distributions and

3   a probabilistic approach is used to arrive at the most preferred alternative (Alvarez-Guerra et

4   al., 2010). In this study the focus was to initiate a structured involvement process facilitated

5   with MCDA. Criteria were selected to reflect the interest of residents, stakeholders and ex-

6   perts, rather than to be a comprehensive baseline for a decision since the project is in an early

7   exploratory phase. The aspect of uncertainty evaluation was therefore not highly prioritized in

8   this study. It is evident that as the project process advances, the selection of MCDA metho-

9   dology should evolve, possibly focusing more on uncertainties in the criteria thus requiring

10   selection of other weighing methods.

11   *Evaluating Advisory Group Perception of the MIP*

12   Within each session of the advisory group meetings the participants were asked with

13   the aid of questionnaires, how they perceived the session and the involvement process. The

14   general impression from both discussions and the results of the questionnaire were that people

15   were in agreement that the involvement and learning process was positive in terms of infor-

16   mation exchange between both expert witnesses and the advisory groups. These results are

17   encouraging for the future application of MIP as it indicates a successful exchange of infor-

18   mation and that both residents and stakeholders can produce valuable advice for the manage-

19   ment process, with results well in line with what experts suggest.

20   There are however differences between the dynamics in the groups. The residents par-

21   ticipated using the information and methods available well within the available time of 3

22   meetings. The non-residential experts performed the MIP within 1 meeting reflecting their

23   familiarization with the subject; however, they were occupied with the assumptions made

24   when assessing criteria and criteria weights. The work flow with the stakeholder group was

25   different. Although the meetings were constructive, more time was spent on familiarization,

1   clarification of the mandate for the group and questions relating to the MCDA process. The

2   stakeholders also to some degree questioned the objectives of the study and focused on their

3   role in the forthcoming project process. These discussions about roles and expectations are

4   common in stakeholder involvement processes (Gerrits & Edelenbos, 2004) and emphasize

5   the need to invest time in familiarization and formulation of objectives when addressing

6   stakeholders in the involvement processes (Sjöberg L & Drottz-Sjöberg B.M, 2008). It is also

7   important to consider these differences when deciding what kind of advisory groups to engage

8   in the MIP.

9   **CONCLUSION**

10   In this paper we propose a multi-criterial involvement processes (MIP) to enhance par-

11   ticipatory involvement processes. The evaluation of the Bergen harbor case study supports the

12   feasibility of this method for these processes. This statement is mainly supported by 2 find-

13   ings in the study. The results show that using MCDA as an integral step in the MIP adds

14   structure and robustness to the involvement process and provides good documentation of cri-

15   teria to be further addressed by the problem owner. Secondly, we perceive involvement and

16   learning as important for the participants to be able to perform the MCDA in selection of re-

17   mediation alternatives.

18   There also challenges to use MCDA in an advisory process. Firstly there are consider-

19   ations to make regarding use of MCDA method. In this case the analytical hierarchy process

20   (AHP) was selected due to user friendliness, but other settings may require use of other me-

21   thods which have been shown in the literature to produce more robust results. Secondly this

22   study showed that the quantitative scoring was perceived as problematic and was questioned

23   especially by stakeholders and experts. The interactions and the qualitative information from

24   the different advisory group discussions as suggested in the MIP, are therefore important in

25   order to reduce misunderstandings and misinterpretations.

1   Finally, it is important to remember that the emphasis on method and process should

2   be balanced using both quantitative and qualitative methods as proposed in the MIP. By in-

3   cluding MCDA in the MIP, the structure and documentation of the process is ensured thus

4   providing quantifiable results that can be replicated by third parties. By engaging group inte-

5   raction and learning through participatory methods, the quality of the involvement process

6   from recruitment to final discussions is preserved thus setting the stage for successful sedi-

7   ment remediation projects for both stakeholders and problem owners.

8   **ACKNOWLEDGMENTS**

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2   one standard deviation.

3   Figure 5   Histogram of inconsistency scores for the different advisory groups. Scores for

4   choice between, environmental, societal and economical criteria as well as

5   scores within the environmental and societal criteria are given in the figure.

6   The economical criterion is only 1 pair and has therefore no inconsistency

7   Figure 6   Analysis of the standard deviation within the groups for the different alterna-

8   tives for both intuitive ranking and MCDA

9