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# Application of Interval Type-2 Fuzzy DEMATEL for Evaluation of Environmental Good Governance Components

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**ABSTRACT**

Elaborating an effective solution for improving the quality of environment has gained attentions. Governments have interests in investing in environmental sustainable activities. Despite of these kinds of attempts and introduction of environmental good governance, green issues require a continuous study in the field to gain an advantage. Current study has investigated the components of environmental governance by usage of interval type-2 fuzzy DEMATEL. It has been distinguished that agency and Adaptiveness from elements of environmental governance can determine the changes of the whole system. Besides, there are knowledge, norm, power and scale which play roles as crosscutting themes and their footprints are specified in all the elements. The results show that knowledge and norms have the ability to change the other crosscutting themes while power is more influenced by others. Such findings can help scholars to figure out how they can make the environmental governance have better performance.

**KEYWORDS:** Environmental good governance, Fuzzy sets, Interval type-2 Fuzzy DEMATEL



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# 1. 1 INTRODUCTION

Deforestation, wind and waste mismanagement, light pollution, water and air pollution, destruction of biodiversity, inequitable access of women, indigenous people and poor communities to environmental resources, goods and services and inequitable sharing of benefits arising from the use of such resources, goods and services are the main environmental problems that human being is faced to. It should be accepted that the principal reason for present environmental degradation is the failure of environmental governance (Belbase, 2010). Environmental good governance is used to encounter the problems. Environmental governance has gained a noticeable attention in accordance with sustainable development. During the last decades, there has been an increase in the level of awareness of environmental degradation and the need for environmental governance. The United Nations Conference on the Human Environment (1972) laid the foundation for international treaties and multilateral regulatory frameworks around global environmental issues. The 1992 United Nations Conference on Environment and Development in Rio de Janeiro also laid some important basic work in the area of environmental governance (Jelin, 2000; Mason, 2014; Najam et al., 2006; Watts, 2011). Nowadays, people are more aware of the importance of environmental resources. They understand that these kinds of resources play an important role in the life of the present generation and future ones. Everyone knows that environmental changes such as land degradation, land cover change (from agriculture, forestry, fisheries), freshwater (decline in quantity and quality) and climate change affects ecosystem services and increase soil erosion, cause loss of medical plans or can bring other different negative aspects that affects social welfare (WHO, 2003). That is why different international agencies such as OECD[1] or IISD[2] try to set guidelines in this domain. Even United Nations has shed the light on environmental sustainability. United Nations defines sustainability as a kind of development that meets the needs of present without compromising the ability of future generations to meet their own needs. Sustainable development contains different aspects. However, environmental issues are very important and United Nations has established the UNEP[3]. UNEP leads the efforts of the United Nations family on of the global environment. Its current priorities are environmental aspects of disasters and conflicts, ecosystem management, environmental governance, harmful substances, resource efficiency, and climate change (United Nations, 2015). As it is obvious, governance has huge effects on preserving environment by setting policies and implementation of them. Besides, self-governance of ordinary people can be really helpful. Because of this importance, the concept of environmental good governance has been developed. Actually, Environmental governance is a concept in political ecology and environmental policy that advocates sustainability and different public or private agents play role in it nowadays.

Environmental governance must be at the core of attention in every nation, especially the ones that can get use of different resources. It is obvious that Iran is a country that can benefit from various resources such as fresh water, wind, oil, gas and geothermal power. Exploitation of these resources in shadows of law and transparent performance of officials besides accompaniment of all the people are really important indisputably. This is what that is considered in environmental governance. This is the concept that employment of its components is vital in Iran. Paying attention to the importance of the environmental sustainable development and the role of governance in this way, the main objective of this study is establishment a review of environmental good governance perspectives, definitions, and criteria. Furthermore, the methodology adopted for the evaluation of environmental good governance practices includes a combination of interval type-2 fuzzy set theory and DEMATEL[4] to evaluate environmental

[1] Organization for Economic Co-operation and Development

[2] International Institute for Sustainable Development

[3] United Nations Environment Programme

[4] Decision Making Trial and Evaluation Laboratory

good governance components and determine which of them has more affection on others. Management of the ones that have more affection is more important undoubtedly, and can set the total orientation of the system.

## 2. LITRETURE REVIWE

Table 1. Summary of Previous Researches

| Authors | Elements that are considered |
|---|---|
| APFED (2009) | Accountability, Transparency, Responsiveness, effectiveness and efficiency, equitability, following the rules of law, censuses orientation and participatory are the elements that have been considered in environmental governance. |
| Barau , Al Hosani (2015) | ESG analytic tools: Issues in sustainability<br>Architecture: What arrangements and governance hierarchies are available for tackling the challenge?<br>Agency: Which public/private/international organization is responsible for addressing the challenges and how does it discharge the responsibility?<br>Accountability: What is the quality and effectiveness of agencies and policies for managing existing challenges?<br>Access and allocation: How do public/private organizations plan to achieve balance between people natural resources needs and ecosystem security<br>Adaptiveness: How do institutions adapt to new innovations for sustainability and how do that affect or help environmental sustainability of regional resources<br>Knowledge: How effective and knowledge-based are decisions about development and management of environmental challenges?<br>Norms: What role norms and values play in designing sustainability change issues and local people and governments?<br>Scale: What is scale of institutions local, regional, scale of influence of stakeholders, environmentalists, bureaucrats etc.?<br>Power: Where does power to change ecological threats of desalination industry lie? People? Agencies? Governments? Businesses? Individuals? |
| Belbase (2010) | Transparency, accountability, people's participation, decentralization up to the lowest level of community and the rule of law;<br>Making environment related decisions publicly;<br>Making individuals and communities participate in environmental decision-making processes and discussions;<br>Representation of communities to be affected by environmental decisions;<br>Holding decision makers accountable for the integrity of decision-making procedures and the result of decisions. |
| Biermann et al. (2010) | They developed "5As model" that include these:<br>Architecture: Governance architectures or system of institutions, rules, and decision-making procedures within an issue area;<br>Agency: specially as it is exercised by actors other than government;<br>Adaptiveness: The adaptiveness of governance processes;<br>Accountability: Their accountability and legitimacy in the eyes of those being governed;<br>Allocation: The modes of allocation and access for distributing the benefits and burdens of environmental protection.<br>They also mentioned that these elements should be considered besides of power, scale, knowledge and norms. |
| Handayani | Accessibility of information; participation of different groups; Transparency of |

| | |
|---|---|
| (2013) | performance and policy making; Accountability; Paying attention to human rights. |
| Janicke (2006) | The model that is considered is "RIO Model". The "Rio Model" of Environmental Governance can be seen as an answer to the increasingly complex constellation of actors in different level of individual, local, regional, national, European, global. It is explicitly characterized by:<br>Long-term goals, timeframes, monitoring and assessment (management by objectives); Integration / sectorial strategies; Participation of stakeholders; Co-operation, activated self-regulation; Multi-level co-ordination. |
| Mattor et al. (2014) | They used some questions in order to develop the 5As model:<br>Agency: Defining the ones who are involved in the decision making and the role(s) they play (Who is associated with what internal and/or external drivers? Who is in favor? Who is opposed? How are they involved (design and/or implementation)?);<br>Architecture: Determination of governance mechanism (What is the structure of the decision-making process (horizontal, vertical, etc.)?<br>What is the structure of the rules system (markets, hierarchy, networks, etc.)? How are decisions made and influenced?);<br>Adaptiveness: paying attention to this matter that how the system anticipate and respond to change (Are the changes short-or long-term?<br>Are the changes coming from internal or external sources? What is being impacted? What is adapting to change? Are the changes coming from internal or external sources? What dose cause the impact(s)? Is the governance mechanism capable of anticipating issues/problems/crisis?<br>Where does monitoring fit in?);<br>Allocation and access: Determination of the way that rights and impacts are distributed (Who has access to which resources? Who has access to the decision-making process? Who is impacted by the decisions and/or the decision-making process? How are various resources allocated?);<br>Accountability: Defining the mechanisms for holding agents accountable to each other, policy goals, and the public good (Is the governance mechanism meeting its intended goals? Who are agents held accountable to? Who enforces the rules? How are the rules being enforced? Who are the rules being enforced for? Is the governance mechanism addressing the needs of internal and external interests? Are the rules transparent? What is the process to ensure the governance mechanism meets the public good?) |
| Puppim de Oliveira et al. (2013) | Decision-making process (process dimension: participation and inclusiveness, responsibility and accountability, Decision-making effectiveness); Implementation capacity (capacity dimension: organizational capacity, formal/informal rule building, behavior change); Economic system (green economy dimension: Resource use efficiency, Responsible consumption, Internalization of externalities); Socio-ecological system (socio-ecological dimension: resource conservation, system resilience, human well-being) |

# 3. THEORETICAL FRAMEWORK

## 3.1. Environmental Good Governance

Before defining environmental good governance, it should be mentioned that good governance as a whole, describes the process of decision making and the process by which decisions are implemented or not implemented. Although government and governance seem to be the same, a government usually means a different body and a process rather than citizens, civil society and the private sector. In

governance the government is only a main actor among many different actors. It can be said that all forces that can influence human behaviour are potential tools of governance (Belbase, 2010). OECD has identified the components of good governance as follow (OECD, 2004):

- *Openness, Transparency and Accountability;*

Openness simplifies achievement of a stronger, cleaner, fairer world. This is why OECD try to promote government transparency, fight corruption, empower citizens and maximize the potential of new technologies to strengthen accountability and foster participation in public affairs. Openness and transparency are pillars for democracy, trust and progress.

- *Fairness and equity in behavior and activities with citizens*

Governments should cultivate social justice and try to perform special mechanisms that make it possible for different people to receive public services equally. It must be considered that different levels of people in society are equal and they all must have access to services. Officials must behave fairy with them.

- *Efficient and effective services*

All governments must try to increase efficiency and effectiveness of services and invest in modernization. Some believe that e-government can enhance efficiency and effectiveness, while sustaining ongoing service delivery improvement. The assessment of the benefits realization of e-government projects must be done.

- *Clear and transparent laws and regulations*

Laws must be as clear as people can understand them and their application be known. Transparency, including solicitation of public feedback during the creation of new laws and regulations, open government decision making, and the ability to access information is consistently important in good governance concept.

- *Consistency and coherence in policy formulation*

Governments should adopt, at the political level, broad regulatory management, reform programs, and also establish clear objectives and frameworks for implementation. These programs together can greatly help to increase the consistency of inputs to the decision and regulatory making process, and also to enhance the level of coherence of both processes and policies.

- *Respect rule of law / legal gateways*

The rule of law is naturally a concept against the rule of a person. Accordingly, it needs to be proved that every action of the government is consistent with laws. The actions which are not supported by law or actions that are arbitrary do not fall within the ambit of rule of law (Belbase, 2010).

- *Highest level of standards of ethical behavior of the highest norms*

Most societies have legal rules that govern behavior, but ethical norms tend to be broader and more informal than laws. Although most societies use laws to enforce widely accepted moral standards, ethical and legal rules, it is important to remember that ethics and laws are not the same. An action may be legal but unethical or illegal but ethical. In the last century, many social reformers urged citizens to disobey laws in order to protest what they regarded as immoral or unjust laws (Resnik, 2011). Good governance should pay attention to norms and practical works for changing behaviors of people in order to cultivate self-responsibility.

There are different other definitions about good governance. But paying attention to the highest standards of ethical behavior of the highest norms makes the definition of OECD special somehow. Most of the other

definitions do not pay attention to this matter (OECD, 1997). United Nations defines good governance too. It believes that good governance has 8 major characteristics of participatory, consensus oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follows the rule of law. It assures that corruption is minimized, the views of minorities are taken into account and that the voices of the most vulnerable in society are heard in decision-making. It is also responsive to the present and future needs of society (UNESCAP, 2009).
Now, environmental good governance can be said to be the right to use the natural resources and the environment. The definition of environmental governance includes such norms and values, policies, technologies and organizations through which society ensures sustainable economic growth and social development by managing natural resources in a transparent, accountable, participatory and equitable manner. It means effective environmental governance is attainable only if existence of components of environmental governance in the approaches of different levels of the state is observable (Belbase, 2010). The summary of previous researches about environmental governance is shown in Table 1. Population growth and economic development is not ignorable nowadays. This kind of development is dependent on natural resources more or less. However it is considerable that natural resources constitute a complex social–ecological system that are seen as abundance and scarcity at the same time. The process of steering human–environment interactions through formal and informal institutions, policies, rules, and practices are noticeable for environmental governance because of this situation (Mattor, 2014).

At first, the federal funds were the main responsible center of environmental governance system. But now, the cooperation between public and privates agencies has been deployed and new mechanisms for environmental governance has been emerged. New mechanisms emphasize local level decision-making processes such as citizen science or practice-based judgments and incorporate cross-jurisdictional networks and partnerships. While the old ones did not pay to the matters like this (Mattor, 2014). In addition, the realm of environmental governance is inherently complex, demanding navigation of many kinds of boundaries including jurisdictional, cultural, and disciplinary, and consideration of multiple scales (Sternlieb et al., 2013). So, it is obvious that environmental governance mechanisms have changed over time. New approaches must be taken because of this. New approaches pay attention to learning and behavior change or learning society. They believe that good and effective environmental policy making requires a learning society at its basis. This approach implies that the government is only one part of a national governance system and self-governance through interdependent individuals, groups, organizations and institutions that operate at different levels is a key part of it. So, roles, responsibilities, behavioral expectations, values, vision and goals must be redefined. A core of shared values is necessary for trust and reliable interdependence, effective autonomy and collective action, learning, resilience and adaptability at all levels. This capacity for governance is seen to be at the heart of sustainable human development. The concept of empowerment which means increasing the skills of individuals, groups and communities to make better decisions for them is important for self-governance. It helps public, private and civil society agencies to become partners in an effective way (Allen et al., 2002).

As it is clear, recent studies have paid attention to "5As model". Actually, 5As model is based on findings of "Earth System Governance Project". The Earth System Governance Project is a long-term, interdisciplinary social science research program started from 2009 and will continue till 2018. International Human Dimensions program on Global Environmental Change has the responsibility of the project and cooperate with 300 active scholars. About 1700 scholars are indirectly involved from all continents too. It can be said that it is the largest social science research network in the area of governance and global environmental change. The aim of the Earth System Governance Project is to take up the challenge of exploring political solutions and implementation of an effective governance system to cope with current transitions in the biogeochemical systems of our planet. The normative context of this project is sustainable development in order to see environmental governance not only as a question of governance effectiveness, but also as a challenge for political legitimacy and social justice (Earth System Governance Project, 2015).

"Architecture", "Agency", "Adaptiveness", "Accountability" and "Allocation and access" are the main elements of 5As model. The meaning of these elements has been clarified describing good governance concept. These elements should be used in accordance with four crosscutting themes that are interlinked with them:

*Power* and the nature of it (for example, what are its sources? wow is it exercised in earth system governance?) should be considered in each study that is related to environmental governance. Besides, Power needs to be distinguished from other closely related concepts such as authority and influence.

*Knowledge* and the role of it in studying each of the five elements of 5As model will be important. Research on environmental governance is inevitable. Also research on the role that science plays in this domain must be reflexive, in allowing for improved understanding on the underlying theories, methods, and assumptions of environmental governance.

Norms, values and principles pervade political processes at the national and local level, and hence all research in environmental governance must be placed in the context of local circumstances and local belief-systems. Likewise, norms and principles will be of special relevance at the international level.

*Scale* is important because it must be determined whether certain findings or hypotheses apply on all scales, or are valid merely for one scale (for example only for the international or only for the local level). Likewise, scholars will have to analyze to what extent scale influences their finding. Scale is a central factor in studying all five elements. For one, scale and architecture are closely related. Scale and level determine the frame within which architectures are designed, contested and evaluated (Biermann et al., 2009).

### 3.2. Trapezoidal fuzzy numbers

Trapezoidal fuzzy numbers are defined as $\tilde{m}=(a,b,c,d)$. B and c are called mode interval of $\tilde{m}$, d is upper limit and $a$ is lower limit of it. The membership function is shown as:

$$\mu_m=\begin{cases}\dfrac{x-a}{b-a}(a\le x\le b)\\ 1\quad(b\le x\le c)\\ \dfrac{d-x}{d-c}(c\le x\le d)\end{cases} \tag{1}$$

Considering $\tilde{A},\tilde{B}$ as two trapezoidal fuzzy numbers, the operational laws between them becomes as follow:

$$\tilde{A}+\tilde{B}=(a_1+b_1,a_2+b_2,a_3+b_3,a_4+b_4) \tag{2}$$

$$\tilde{A}-\tilde{B}=(a_1-b_4,a_2-b_3,a_3-b_2,a_4-b_1) \tag{3}$$

$$\tilde{A}\otimes\tilde{B}=(a_1\times b_1,a_2\times b_2,a_3\times b_3,a_4\times b_4) \tag{4}$$

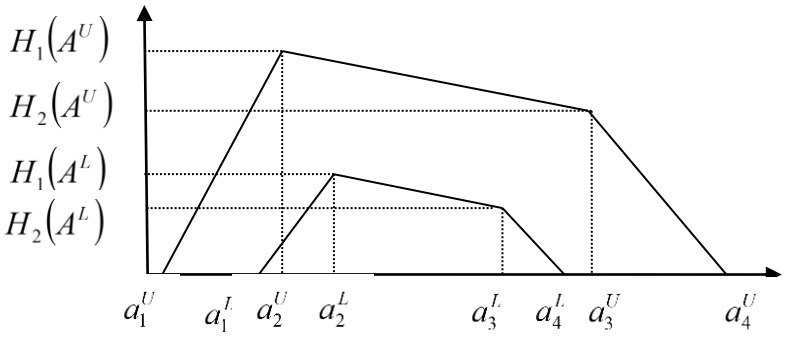
$$(\tilde{A})^{-1}=\left(\frac{1}{a_4},\frac{1}{a_3},\frac{1}{a_2},\frac{1}{a_1}\right) \tag{5}$$

### 3.3. Interval type-2 fuzzy set

Type-2 fuzzy sets consider more uncertainty in comparison with generalize Type-1 fuzzy sets and systems. Criticisms have been always raised about this matter that the membership function of type-1 fuzzy set does not indicate any uncertainty. This despites the fact that fuzzy concept has the connotation of lots of

uncertainty. Interval type-2 fuzzy set is an especial type. It transfers the uncertainty of membership by usage of interval value (see figure 1).

Figure 1. Membership function of an interval type-2 fuzzy number




Consider A, B as two trapezoidal interval type-2 fuzzy numbers. The laws of calculations between them are as follow:

$$A=\left(A^U,A^L\right)=\left(\left(a_1^U,a_2^U,a_3^U,a_4^U;H_1\left(A^U\right),H_2\left(A^U\right)\right),\left(a_1^L,a_2^L,a_3^L,a_4^L;H_1\left(A^L\right),H_2\left(A^L\right)\right)\right) \quad (6)$$

$$B=\left(B^U,B^L\right)=\left(\left(b_1^U,b_2^U,b_3^U,b_4^U;H_1\left(B^U\right),H_2\left(B^U\right)\right),\left(b_1^L,b_2^L,b_3^L,b_4^L;H_1\left(B^L\right),H_2\left(B^L\right)\right)\right) \quad (7)$$

$$kA=\left(A^U,A^L\right)=\begin{pmatrix}\left(ka_1^U,ka_2^U,ka_3^U,ka_4^U;H_1\left(A^U\right),H_2\left(A^U\right)\right),\\ \left(ka_1^L,ka_2^L,ka_3^L,ka_4^L;H_1\left(A^L\right),H_2\left(A^L\right)\right)\end{pmatrix} \quad (8)$$

$$\frac{1}{k}A=\left(A^U,A^L\right)=\begin{pmatrix}\left(\frac{1}{k}a_1^U,\frac{1}{k}a_2^U,\frac{1}{k}a_3^U,\frac{1}{k}a_4^U;H_1\left(A^U\right),H_2\left(A^U\right)\right),\\ \left(\frac{1}{k}a_1^L,\frac{1}{k}a_2^L,\frac{1}{k}a_3^L,\frac{1}{k}a_4^L;H_1\left(A^L\right),H_2\left(A^L\right)\right)\end{pmatrix} \quad (9)$$

$$A+B=\left(A^U,A^L\right)+\left(B^U,B^L\right)=\begin{pmatrix}\left(a_1^U+b_1^U,a_2^U+b_2^U,a_3^U+b_3^U,a_4^U+b_4^U;\min\left(H_1\left(A^U\right),H_1\left(B^U\right)\right),\right.\\ \left.\min\left(H_2\left(A^U\right),H_2\left(B^U\right)\right)\right),\\ \left(a_1^L+b_1^L,a_2^L+b_2^L,a_3^L+b_3^L,a_4^L+b_4^L;\min\left(H_1\left(A^L\right),H_1\left(B^L\right)\right),\right.\\ \left.\min\left(H_2\left(A^L\right),H_2\left(B^L\right)\right)\right)\end{pmatrix} \quad (10)$$

$$A-B=\left(A^U,A^L\right)-\left(B^U,B^L\right)=\begin{pmatrix}\left(a_1^U-b_4^U,a_2^U-b_3^U,a_3^U-b_2^U,a_4^U-b_1^U;\min\left(H_1\left(A^U\right),H_1\left(B^U\right)\right),\right.\\ \left.\min\left(H_2\left(A^U\right),H_2\left(B^U\right)\right)\right),\\ \left(a_1^L+b_4^L,a_2^L-b_3^L,a_3^L-b_2^L,a_4^L-b_1^L;\min\left(H_1\left(A^L\right),H_1\left(B^L\right)\right),\right.\\ \left.\min\left(H_2\left(A^L\right),H_2\left(B^L\right)\right)\right)\end{pmatrix} \quad (11)$$

$$A \otimes B = \left(A^U, A^L\right) + \left(B^U, B^L\right) = \left( \begin{pmatrix} a_1^U \times b_1^U, a_2^U \times b_2^U, a_3^U \times b_3^U, a_4^U \times b_4^U; \min\left(H_1\left(A^U\right), H_1\left(B^U\right)\right), \\ \min\left(H_2\left(A^U\right), H_2\left(B^U\right)\right) \end{pmatrix}, \begin{pmatrix} a_1^L \times b_1^L, a_2^L \times b_2^L, a_3^L \times b_3^L, a_4^L \times b_4^L; \min\left(H_1\left(A^L\right), H_1\left(B^L\right)\right), \\ \min\left(H_2\left(A^L\right), H_2\left(B^L\right)\right) \end{pmatrix} \right) \quad (12)$$

As is clear, the laws of calculation in interval type-2 fuzzy set are so close to the laws of general type-1 fuzzy set. So, anyone who is familiar with the fuzzy sets can easily take advantage of the uncertainty in the membership function of interval type-2 fuzzy set. A crisp number (like C) can simply turn to interval type-2 fuzzy number (c, c, c, c; 1, 1) (Abdullah, Zulkifli, 2015).

## 4. METHODOLOGY

Academics and practitioners have come to recognize that the global environmental sustainability requires innovative research approaches to address the complexity of social–ecological systems better. Current study, according to its direction and objectives, is a kind of descriptive research. Moreover, it can be considered as survey research too. It was said that models of environmental governance are focused on different elements. But current approaches emphasis that norms and social capital must be considered in order to let ordinary people to have more participation in environmental governance. "5As model" (Biermann et al., 2010) has considered these matters and is used in more recent studies such as Mattor et al. (2014). In addition, "5As model" is consistent with OECD or United Nations policies about environmental governance. That is why this model has been considered to be evaluated in current study.

"5As model" has 5 main elements of "Architecture", "Agency", "Adaptiveness", "Accountability", "Allocation and access". These elements are highly interlinked. There are also 4 crosscutting themes that are really important in evaluation of each element. These crosscutting themes help the "5As model" to be in accordance with current mentality about environmental governance. Crosscutting themes are "power", "scale", "knowledge" and "norms".

For determining the mutual effects of the elements and crosscutting themes used in "5As model", DEMATEL method has been applied. This method with the aid of structural modeling approach, divide the elements into two separate categories- cause and effect. This helps the scholars to gain a better understanding of the structural relationships between the components (Li et al., 2014; Lin, 2011). DEMATEL is used twice. Once for evaluation of elements of "5As model" and the other one for evaluation of crosscutting themes considered in it.

The vast majority of organizations for dealing with the decision making issues, faced with in the real world, apply the group decision making methods. But while we are confronting the complicated systems, the experts' opinion becomes more explanatory and gives up its absolute values. This sort of opinions makes the decision making process much more complicated and causes the ambiguity. Therefore, the fuzzy theory is developed by Dr. Asgarzadeh in order to take advantages of ambiguous data in analyzing the matters (Zadeh, 1965). Meanwhile, Interval type-2 fuzzy set transfers the uncertainty better. So, interval type-2 fuzzy DEMATEL is used to differentiate the components that affects other components of the systems (cause group) from the ones that receives effects from others (effect group) (Abdullah, Zulkifli, 2015). Data have been gathered based on the questionnaire measurement tool which was sent to 13 experts in industry or university, in order to get their professional opinion. Selected experts are experienced and well-informed about the managerial knowledge and concepts used in questionnaire (see Table 2) (Abdullah, Najib 2014).

Table 2. Linguistic variables used in questionnaire in order to catch opinions

| Linguistic variables | Interval type-2 fuzzy numbers |
|---|---|
| Very high influence | ((0.8, 0.9, 0.9, 1.0; 1, 1), (0.85, 0.9, 0.9, 0.95; 0.9, 0.9)) |
| High influence | ((0.6, 0.7, 0.7, 0.8; 1, 1), (0.65, 0.7, 0.7, 0.75; 0.9, 0.9)) |
| Low influence | ((0.4, 0.5, 0.5, 0.6; 1, 1), (0.45, 0.5, 0.5, 0.55; 0.9, 0.9)) |
| Very low influence | ((0.2, 0.3, 0.3, 0.4; 1, 1), (0.25, 0.3, 0.3, 0.35; 0.9, 0.9)) |
| No influence | ((0, 0.1, 0.1, 0.1; 1, 1), (0, 0.1, 0.1, 0.05; 0.9, 0.9)) |

Interval type-2 fuzzy DEMATEL is developed by Abdullah and Zulkifli (2015). Its main steps are the same as traditional DEMATEL. The amount of affection each component has on others is determined by each expert and usage of scale shown in table 2. The opinions are integrated by averaging the individual expert scores and initial direct-relation matrix is determined in this way (H is the number of experts).

$$A = \frac{1}{H}\sum_{k=1}^{H} x_{ij}^{k}$$

Initial direct-relation matrix is normalized by paying attention to equation 12 and 13 where S is the maximum aggregate amount of rows and columns of matrix A. The aggregate amount of rows show the amount of effect each component has on others while the aggregate amount of columns illustrate the amount of effect each component receives from others.

$$D = \frac{A}{s}$$

$$s = \max\left(\max_{1 \le i \le n}\sum_{j=1}^{n} A_{ij}, \max_{1 \le i \le n}\sum_{i=1}^{n} A_{ij}\right)$$

The total relation matrix (T) is obtained at next step. Matrix Z is constructed by arranging matrix D according to the membership functions. There must be 8 matrixes. Showing the interval fuzzy number with ((a,b,c,d;e,f), (g,h,i,j;k,l)), then matrices Za, Zb, Zc, Zd, Zg, Zh, Zi and Zj must be calculated. Similarly, different matrix T ($T_a$, $T_b$, $T_c$, $T_d$, $T_g$, $T_h$, $T_i$ and $T_j$) are obtained. I is the identity matrix at equation 14. Total relation matrix (Ta) of 5 elements and 4 crosscutting themes are shown at table 3 and 4.

$$T = Z(I - Z)^{-1} \qquad (14)$$

Table 3. Total relationship matrix (Ta) of 5 elements

| | Architecture | Agency | Adaptiveness | Accountability | Allocation and access |
|---|---|---|---|---|---|
| Architecture | 0.2137 | 0.2837 | 0.3264 | 0.3784 | 0.3184 |
| Agency | 0.3803 | 0.1962 | 0.3583 | 0.3705 | 0.3517 |
| Adaptiveness | 0.4226 | 0.4031 | 0.3173 | 0.5162 | 0.4953 |
| Accountability | 0.4293 | 0.3598 | 0.4832 | 0.3093 | 0.4356 |
| Allocation and access | 0.4095 | 0.3267 | 0.4355 | 0.4342 | 0.2665 |

Table 4. Total relationship matrix (Ta) of 4 crosscutting themes

| | Power | Scale | Knowledge | Norms |
|---|---|---|---|---|
| Power | 0.2428 | 0.3509 | 0.3441 | 0.3201 |
| Scale | 0.4214 | 0.242 | 0.4068 | 0.3736 |
| Knowledge | 0.6013 | 0.5172 | 0.3181 | 0.5332 |
| Norms | 0.5605 | 0.4656 | 0.4565 | 0.2788 |

For providing the cause and effect's graph, the total sums of each column and row of the total relationship Matrix (called in turn R and D) are obtained. The higher amount of (R+D) means that the relevant component has many interaction (or relationships) with other components and as a result, gets a lot of importance. When (D–R) indicates a positive amount, it can be said that this component has been the superior one. Finally, the cause and effect's graph is made by drawing the points with the coordinates of (R+D, D–R). Before that, the expected values of interval type-2 fuzzy numbers must be attained by usage of equation 15.

$$E(A)=\frac{1}{2}\left(\frac{1}{4}\sum_{i=1}^{4}A_i^U+A_i^L\right)+\frac{1}{4}\left(\sum_{i=1}^{4}H_i^U+H_i^L\right) \quad (15)$$

## 5. RESEARCH FINDING

Total effect that a component has on other elements (D) and total effect that receives from others can be obtained based on total relationship matrix. The same process is possible for cross cutting themes (see Table 5 and Table 6).

Table 5. Elements and their values of R & D

| | **D** | **R** | **D+R** | **D-R** |
|---|---|---|---|---|
| Architecture | (1.5206,2.7497, 2.7497,6.4392:1 ,1),(2.0074,2.74 97,2.7497,3.955 6:0.,0.9) | (1.8554,3.2269, 3.2269,7.3739:1 ,1),(2.4017,3.22 69,3.2269,4.587 2:0.9,0.9) | (3.376,5.9766,5. 9766,13.8131:1, 1),(4.4091,5.976 6,5.9766,8.5428 :0.9,0.9) | (-0.3348,- 0.4772,-0.4772,- 0.9347:1,1),(- 0.3943,-0.4772,- 0.4772,-0. 6316:0.9,0.9) |
| Agency | (1.657,2.948,2. 948,6.8217:1,1) ,(2.1682,2.948, 2.948,4.2137:0. 9,0.9) | (1.5695,2.8207, 2.8207,6.5689:1 ,1),(2.0651,2.82 07,2.8207,4.048 :0.9,0.9) | (3.2265,5.7687, 5.7687,13.3906: 1,1),(4.2333,5.7 687,5.7687,8.26 17:0.9,0.9) | (0.0875,0.1273, 0.1273,0.2528:1 ,1),(0.1031,0.12 73,0.1273,0.165 7:0.9,0.9) |
| Adaptiveness | (2.1545,3.6655, 3.6655,8.2003:1 ,1),(2.7598,3.66 55,3.6655,5.150 3:0.9,0.9) | (1.9207,3.3276, 3.3276,7.5538:1 ,1),(2.4816,3.32 76,3.3276,4.709 :0.9,0.9) | (4.0752,6.9931, 6.9931,15.7541: 1,1),(5.2414,6.9 931,6.9931,9.85 93:0.9,0.9) | (0.2338,0.3379, 0.3379,0.6465:1 ,1),(0.2782,0.33 79,0.3379,0.441 3:0.9,0.9) |

| | | | | |
|---|---|---|---|---|
| Accountability | (1.5206,3.4638,3.4638,7.8226:1,1),(2.5953,3.4638,3.4638,4.8909:0.9,0.9) | (2.0086,3.4514,3.4514,7.8004:1,1),(2.5852,3.4514,3.4514,4.8755:0.9,0.9) | (3.5292,6.9152,6.9152,15.623:1,1),(5.1805,6.9152,6.9152,9.7664:0.9,0.9) | (-0.488,0.0124,0.0124,0.0222:1,1),(0.0101,0.0124,0.0124,0.0154:0.9,0.9) |
| Allocation and access | (1.8724,3.2505,3.2505,7.419:1,1),(2.4218,3.2505,3.2505,4.6182:0.9,0.9) | (1.8675,3.2509,3.2509,7.4058:1,1),(2.4189,3.2509,3.2509,4.609:0.9,0.9) | (3.7399,6.5014,6.5014,14.8248:1,1),(4.8407,6.5014,6.5014,9.2272:0.9,0.9) | (0.0049,-0.0004,-0.0004,0.0132:1,1),(0.0029,-0.0004,-0.0004,0.0092:0.9,0.9) |

Table 6. Crosscutting themes and their value of R & D

| | D | R | D+R | D-R |
|---|---|---|---|---|
| Power | (1.2579,1.6666,1.66666,4.6021:1,1),(1.6373,1.6666,1.6666,2.8842:0.9,0.9) | (1.826,2.4055,2.4055,5.9163:1,1),(2.2718,2.4055,2.4055,3.7888:0.9,0.9) | (3.0839,4.0721,4.0721,10.5184:1,1),(3.9091,4.0721,4.0721,6.673:0.9,0.9) | (-0.5681,-0.7389,-0.7389,-1.3142:1,1),(-0.6345,-0.7389,-0.7389,-0.9046:0.9,0.9) |
| Scale | (1.4438,2.3409,2.3409,5.4074:1,1),(1.8333,2.3409,2.33409,3.1628:0.9,0.9) | (1.5757,2.5332,2.5332,5.326:1,1),(1.9871,2.5332,2.5332,3.3828:0.9,0.9) | (3.0195,4.8741,4.8741,10.7334:1,1),(3.8204,4.8741,4.8741,6.5456:0.9,0.9) | (-0.1319,-0.1923,-0.1923,0.0814:1,1),(-0.1538,-0.1923,-0.1923,-0.22:0.9,0.9) |
| Knowledge | (1.9698,3.0567,3.0567,4.0267:1,1),(2.4384,3.0567,3.0567,4.0267:0.9,0.9) | (1.5255,2.4551,2.4551,5.5443:1,1),(1.9274,2.4551,2.4551,3.2976:0.9,0.9) | (3.4953,5.5118,5.5118,11.7817:1,1),(4.3658,5.5118,5.5118,7.3243:0.9,0.9) | (0.4443,0.6016,0.6016,0.6931:1,1),(0.511,0.6016,0.6016,0.7291:0.9,0.9) |
| Norms | (1.7614,2.7825,2.7825,5.7428:1,1),(2.198,2.7825,2.7825,3.6842:0.9,0.9) | (1.5057,2.4529,2.4529,5.2031:1),(1.9207,2.4529,2.4529,3.2887:0.9,0.9) | (3.2671,5.2354,5.2354,10.9459:1,1),(4.1187,5.2354,5.2354,6.9729:0.9,0.9) | (0.2557,0.3296,0.3296,0.5397:1,1),(0.2773,0.3296,0.3296,0.3955:0.9,0.9) |

As it is said, (D+R) shows the total mutational relationship each component has with others while (D-R) indicates the net effect of each component on others. (D+R) transfers the importance of the component. While the amount of (D+R) is high, it means that the component is more connected to others and deserves more attention because of this. When (D-R) is positive, it means that the component affects the others so it can be grouped into the "cause group". The factor will receives more affection from others and should take a place in "effect group" if (D-R) is negative.

So, DEMATEL can divide the enormous sets of components in to the cause and effect groups and help the decision-maker to understand the conditions much better. A graph can be mapped to make the situation clearer. (D+R) is the horizontal axis of the graph which is called importance axis. (D-R) is the vertical axis of the graph which is called relationship axis. With applying this procedure, the cause and effect graph that is comprised of elements and crosscutting themes, will be as figure 2 and 3. But before that, the crisp amount of (D+R) and (D-R) is shown in table 7 by get use of equation 15.

Table 7. Crisp amount of (D+R) and (D-R)

| | D+R | Rank based on (D+R) | D-R | Rank based on (D-R) |
|---|---|---|---|---|
| Architecture | 6.41812875 | 5 | -0.49924875 | 5 |
| Agency | 7.4733625 | 1 | 0.132798125 | 2 |
| Adaptiveness | 7.46966 | 2 | 0.35047875 | 1 |
| Accountability | 7.33398813 | 3 | -0.046395625 | 4 |
| Allocation and access | 6.96328625 | 4 | 0.00339625 | 3 |
| Power | 4.806145 | 4 | -0.75726875 | 4 |
| Scale | 5.179316875 | 3 | -0.141728125 | 3 |
| Knowledge | 5.820448125 | 1 | 0.568088125 | 1 |
| Norms | 5.49173625 | 2 | 0.33090875 | 2 |

As is clear, “Agency” has got the highest amount of (D+R) and “Adaptivess” earned second place. The result is logic. At first, it must be determined which agents drive environmental governance and that need to be involved. The influence, roles and responsibilities of actors apart from national governments, such as business and non-profit organizations, the ways in which authority is granted to these agents, and how it is exercised must become clarified before going furthered. The next one is “Adaptiveness”. Environmental governance must be capable of facing the inherent uncertainties in human and natural systems. It must pay attention to stability in order to ensure long-term governance with flexibility to react quickly to new findings and developments.

It is interesting that “Adaptivenss” and “Agency” has the first and second rank in (D-R) while “Allocation and access” is the third one. These elements have got the positive amount of (D-R). So they take a place in “Cause group” and they have influence on others more than getting affection from them. For this, decision makers should pay special attention to the agencies participate in governance, flexibility of the system and allocation of the resources or responsibilities. Because, changes of these elements result in a change of the whole system and in this way we can determine the orientation of the whole system. “Architecture” and “Accountability” have got negative (D-R). So they will be in “Effect group”. “Architecture” is most influenced by others. Clearly, the involved agents and their responsibilities, environmental targets, the mechanisms of adaptiveness, accountability and allocation must be determined in order to set the architecture of the whole system.

The same analysis is possible for crosscutting themes. Due to the (D+R) that is specified, “Knowledge” and “Norm” matter most. These crosscutting themes have positive amount of (D-R). Therefore, making changes in “Knowledge” and “Norm” can determine the whole system approach of crosscutting themes. While “Power”, is the element that gets the most affection from others. It is clear that in a knowledge-based society, knowledge and proficiency receive respect.

Figure 2. The cause and effect graph of 5 elements

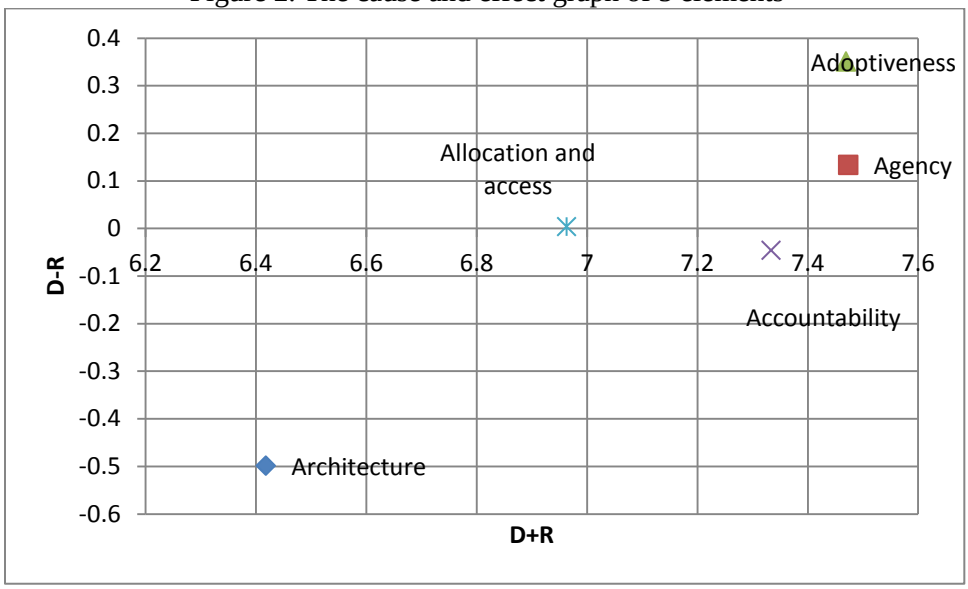
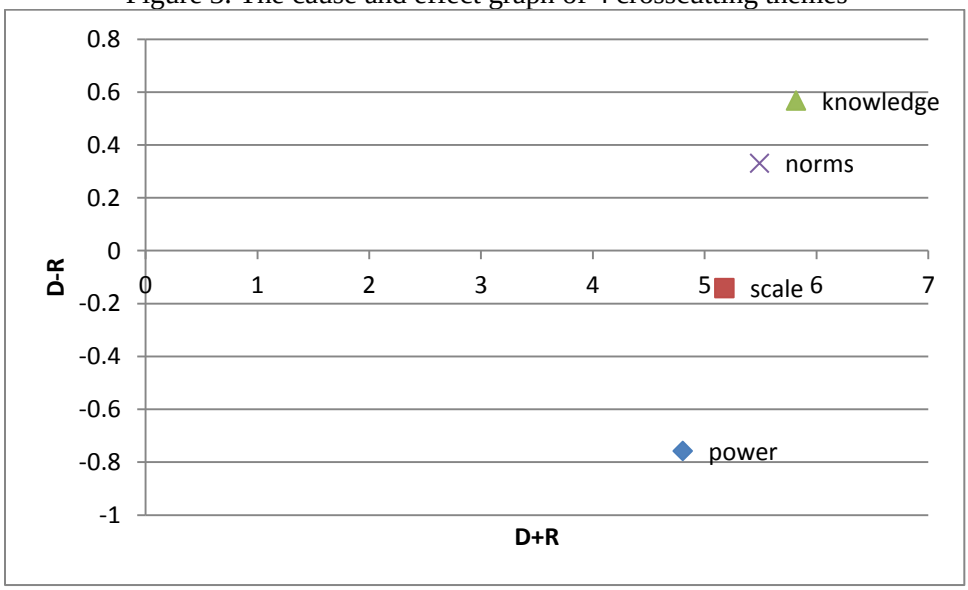



Figure 3. The cause and effect graph of 4 crosscutting themes




## 6. CONCLUSION

This study has taken into consideration the investigation of effective components in executing the environmental governance, in order to give a better understanding of sustainable environmental development. DEMATEL method has been used with the intention of determining the mutual relationships between the effective components in the environmental governance. Since the interval type-2 fuzzy sets theory can remove any ambiguity relevant to the explanatory figures, it has been applied for developing the group DEMATEL method. The interval type-2 fuzzy DEMATEL method can divide the components into two cause and effect groups. The results indicate that “Adaptivness” and “Agency” constitute the cause group among the 5 elements considered in “5As model”. It means that trying to

change them into the desirable way cause the whole elements to change in that way. "Architecture" is affected more than others. In this way, policy makers can change it easily by making changes in others.
The same analysis shows that "Knowledge" and "Norm" form the cause group paying attention to crosscutting themes. Such an outcome is not difficult to understand. Environmental governance should be knowledge-based in order to become successful. Besides that, people's norms control their main behavioral approach. That is why "power" receives the most affection. At a knowledge based society, knowledge and proficiency determine the power of people who are involved in a system.

This study got usage of interval type-2 fuzzy DEMATEL in order to help decision makers better understand the situation. But there can be some suggestions for further studies:

- Interval type-2 fuzzy DEMATEL can be combined with ANP1 technique in order to determine the weight of each elements or crosscutting themes.

- Elements can be used as input or output of "Data Envelopment Analysis" technique in order to make comparison of performance of different agencies possible in this domain.

- Usage of dynamic system concept can be helpful in determination of relationships of agents and the effect of environmental governance mechanisms.

- Such approach can be used to analyze the components of sustainable development. Sustainable development is constituted of environmental, social and economic as main elements and different sub-elements.

- Different mechanisms of environmental governance should be investigated to see how they can affect the environmental performance of various industries. So, it is better to determine the priority of industries at first.

- Since self-governance is highly effective in protecting the environment, ways to improve self-governance of public should be investigated. It must become clear how the right culture of preserving environment will cultivate in a society.

[1] Analytical Network Process

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## ETHICAL CONSIDERATION

Authenticity of the texts, honesty and fidelity has been observed.

## CONFLICT OF INTEREST

Author/s confirmed no conflict of interest.