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ENVIRONMENTAL INSTITUTION IMPROVEMENT USING INTERPRETATIVE STRUCTURAL MODELING (ISM) TECHNIQUES IN LORE LINDU NATIONAL PARK (LLNP), CENTRAL OF SULAWESI PROVINCE-INDONESIA

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ABSTRACT

This study aims to analyze the institutional capacity building of the Lore Lindu National Park, determine the objective mechanisms and constraints for the development of the Lore Lindu National Park, and design alternative designs for the LLNP institution. The research data were obtained by conducting interviews, observation, and focus group discussions using the Structural Interpretation Modeling analysis technique used to formulate institutional alternatives in the future. The results of the institutional analysis show that the key element in the Lore Lindu National Park management program is the Lore Lindu National Park Hall, which is a sub-driving element at the first level in the hierarchical structure and requires support from stakeholders and local government, especially traditional leaders and community leaders. The main obstacle to LLNP management, which is a key element, is the massive illegal clearing of land in LLNP, weak monitoring and control of illegal activities in LLNP, and lack of coordination and integration of natural resource management among stakeholders related to LLNP management. The results of the Interpretative Structural Modeling (ISM) analysis are expected between stakeholders, ministerial agencies, and local governments to guarantee partnerships for the sustainability of the Lore Lindu National Park not only for now but also for the future.
Keywords L Institutional, Interpretative Structural Modeling, Lore Lindu National Park

Introduction

The Lore Lindu National Park (LLNP) is a conservation area of biological natural resources in Central Sulawesi Province which was stipulated by a Decree of the Minister of Forestry No. 593/kpts-ii/1993 with an area of 229,000 hectares. LLNP plays an important role as a buffer zone, especially for the City of Palu, Donggala, and the District of Poso. LLNP is administratively located in Donggala (Kulawi, Sigibiromaru, Palolo and Pipikoro Districts) and Poso (North Lore, Central Lore, East Lore, Lore Piore, West Lore, and South Lore Districts), Central Sulawesi Province. This area has been established since 1993, which is a combination of the Lore Kalamata Nature Reserve and the Lake Lindu Protected Forest and Recreation Park. Biogeographically, this area is a transitional area between the Asian Zone and the Australian Zone or called the Wallace Line which stretches from the Nani Wartabone National Park in Bolaang Mongondou to Donggala and Poso across the LLNP forest and penetrates tropical forests in Southeast Sulawesi.

Not far from Lake Poso which is unique and has millions of charms. Approximately 60 km west of Palu, LLNP is a world natural heritage forest which is very rich in flora and fauna diversity. The purpose of this area is not only for the recreation of mountain climbing, rock climbing while enjoying the beautiful and cool natural scenery, it is also the object of research for domestic and foreign researchers. LLNP is also a world biosphere reserve. The dominant flora potential in the LLNP area are Wanga trees (*Figafeta filaris* sp.) And Leda (*Eucalyptus deglupta*). Furthermore, the potential fauna that can be found in the area includes Anoa (*Anoa quarlesi, Anoa depressicornis*), deer pig (*Babyrousa babyrusa*), Sulawesi Black monkey (*Macaca tonkeana*), cuscus (*Phalanger ursinus, Phalanger celebencis*), Tangkasi (*Tarsius spectrum*), and Deer (*Cervus timorensis*). Endemic bird species found include Maleo (*Macrocephalon maleo*), Hornbill (*Buceros rhinoceros*), parrot (*Tanygnatus sumatrana*), cockatoo (*Cacatua sulphurea*), and (*Aceros cassidix*) and snake cormorant (*Anhinga rufa*). Also live a variety of reptiles, fish, and insects (https://indotimnet. wordpress. com/taman-nasional-lore-lindu).

It is estimated that there are 266 types of flora, some of which are endemic and as new animals, and more than 200 types of fauna, some of which are endemic, are found in the LLNP area such as Anoa, Deer Pig, Black monkey, Tarsius, Maleo, and Sulawesi hornbill. There are 21 types of large lizards, 68 types of snakes, 21 types of amphibians, and 6 types of fish, and thousands of insects including butterflies, so this area is also known as the Megabiodiversity area. Furthermore, most of the people around LLNP still maintain local wisdom values so that the LLNP area is also known as a Biosphere Reserve, which was established by UNESCO in 1977. "The management of LLNP in general aims to realize the management vision of realizing the LLNP and KSDAHE areas. which is safe, secure, legally formal and participatory, supported by strong institutions in its management and able to provide optimal benefits to the community, "(http:// radarsultengonline.com/2017/01/13/mengenal-wisata-alam-lore-lindu-and-history/ Getting to know Lore Lindu Nature Tourism and its History).

The importance of institutional analysis in the LLNP area is due to the complex nature of LLNP management because it includes cross-sectoral, cross-regional interests, and involves many stakeholders. Thus, that requires the integration of several stakeholder roles, especially policymakers to maintain the continuity of the functions and benefits of LLNP. Interpretative Structural Modeling (ISM) is a method that can be used to facilitate understanding of the complex problems faced in LLNP management.

Therefore, it is very important to examine the factors that influence the institutional elements of LLNP management, both directly and indirectly, compiled into a comprehensive systematic model (Attri, 2013). The key institutional elements are identified, their contextual relationships are determined, classified, and arranged hierarchically. The results of the ISM analysis can provide an overview of the institutional hierarchical structure that provides the highest value of benefits to design an effective institutional system and encourage better decision making (Eriyatno and Larasati in Pancawati 2018).

The objectives of the implementation of this research are 1) how to determine the institutional capacity of Lore Lindu National Park; 2) what is the objective mechanism and constraints for the development of Lore Lindu National Park; 3) how to design alternative LLNP institutional designs.

Materials and Method

The location and time of the study

Sampling, data, and information were conducted from August to October 2018 in the Lore Lindu National Park, Central Sulawesi Province, Indonesia. The research data was obtained by conducting interviews, observations, and focus group discussions on 7 experts. According to Hora (2004) stated that the number of experts who are adequate and have high precision is 3 to 6 or 7 people. While expert respondents are experts who meet the criteria as experts (Yusuf 2017), including; 1) expertise or expertise at the academic or researcher level, 2) expertise as a decision-maker and 3) expertise due to specificity such as local wisdom experts. The stages of conducting ISM are divided into two parts, namely the preparation of hierarchies and classification of sub-elements (Eriyatno, 2003).

Interpretive Structural Modeling (ISM) analysis is intended to formulate a management model for the Lore Lindu National Park in Central Sulawesi Province. ISM is a computer-based technique that can help groups identify the relationship between ideas and structures on a complex issue, where the form of this method is the focus learning process. Saxena *et al*. (1992) explain the ISM technique is related to the interpretation of a complete object or system representation through the application of systematic and interactive graphical theory. The use of the ISM method has also been widely used, especially to analyze structural elements based on their contextual relationships (Saxena *et al*., 1992; Machfud, 2001; Marimin, 2004). Eriyatno (2003) highlight the ISM methodology or technique is divided into two parts, namely hierarchical arrangement, and sub-element classification. The basic principle is that the identification of structures within a system will provide high-value benefits to formulate the system effectively and for better decision making. The ISM stage will be divided into two parts, namely hierarchical arrangement and sub-element classification (Eriyatno and Sofyar 2007). Therefore, the steps to be carried out are as follows:

a. Identification of study elements, in this case, the elements of opportunity and constraints in raw water management in the Province of Bangka Belitung Islands.
b. Identification of sub-elements.
c. Determine the contextual relationship between sub-elements that contain a direction in sub-ordinate terminology leading to pairwise comparisons based on expert opinion (expert judgment). The relationship between these elements is expressed in cartesian multiplication. The matrix must meet reflexive and transitive properties (Machfud, 2001). In the process of transforming a contextual relationship (Matrix Structural Self-Interaction) into a mathematical relationship in the form of a Reachability Matrix with the complete rules in the following table.

Table 1 : Transformation of the contextual relationship between sub-elements (SSIM) into a mathematical relationship (RM)

Forms of Contextual Relationships Between Elements i and j (eij)	Mathematical Relationships Between Elements i and j (eij)
V	If eij=1 dan eij=0
A	If eij=0 dan eij=1
X	If eij=1 dan eij=1
O	If eij=0 dan eij=0

a. V if $e_{ij} = 1$ and $e_{ji} = 0$; V = the ith sub-element should be handled first than the j_{-th} sub-element (the relation of elements Ei to Ej, but does not apply to the inverse).
b. A if $e_{ij} = 0$ and $e_{ji} = 1$; A = the j_{-th} sub-element should be handled first than the i_{-th} sub-element (the relation from Ej to Ei, but does not apply to the reverse).
c. X if eij = 1 and eji = 1; X = the two sub-elements must be handled together (the inter-relation between Ei and Ej or applies to both directions).
d. O if eij = 0 and eji = 0; O = the two sub-elements are not the priority handled (representing that Ei and Ej are not related).
e. The meaning of the value of eij = 1 is the contextual relationship between the i and j sub-elements, while the

value of eij = 0 is the absence of a contextual relationship between the ith and jth sub-elements.

f. The results of these calculations are arranged in a structural self-interaction matrix (SSIM). SSIM is made in the form of a reachability matrix (RM) table by replacing V, A, X, and O into the numbers 1 and 0.

After the structural self-interaction matrix (SSIM) is filled in base on the respondent's opinion, the symbols (V, A, X, O) can be replaced with symbols (1 and 0) following the provisions so that from there it can be seen the value of the final element reachability matrix (RM). The form of filling in the final element reachability matrix (RM) results is presented in the following table.

Table 2 : Results of the final element reachability matrix (RM)

	1	2	3	4	5	6	7	8	9	...	...	n
1												
2												
3												
4												
5												
6												
7												
8												
9												
...												
...												
n												

After the structural self-interaction matrix (SSIM) is filled in according to the respondent's opinion, the symbols (V, A, X, O) can be replaced with symbols (1 and 0) following the provisions so that the value of the final element reachability matrix (RM) can be determined. The form of filling in the final element reachability matrix (RM) results is presented in the following table.

Table 3 : Results of the final element reachability matrix (RM)

	1	2	3	4	5	6	7	8	9	...	...	n	DP	R
1														
2														
3														
4														
5														
6														
7														
8														
9														
...														
...														
n														
D														
L														

Note: DP (driven power), R (rank), D (dependence), L (level / hierarchy)

Based on the table above, it can be seen the value of the driven power by adding the horizontal sub-element values; the ranking value is determined based on the value of the power driver, which is sorted from largest to smallest; the dependence value is obtained from the sum of the vertical sub-element values; for the level, value is determined based on the value of the dependence which is sorted from largest to smallest. Broadly speaking, the sub-element classification is classified into 4 sectors. The matrix analysis of the sub-element classification is presented in the following figure:

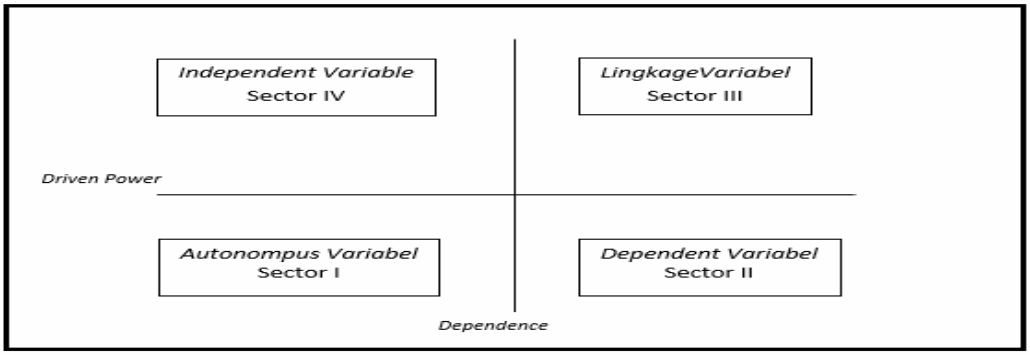

Fig. 1 : Graph of influence and dependence between sub-elements

a. Sector 1; weak driver-weak dependent variables (autonomous). The sub-elements that enter into this sector are generally unrelated to the system and may have a few links, although they may be strong. Sub-elements that enter sector 1 if: DP value ≤ 0.5 X and D value ≤ 0.5 X, X is the number of sub-elements.
b. Sector 2; weak driver-strongly dependent variables (dependent). Generally, the sub-elements that are included in this sector are those that are not independent. The sub-elements that enter sector 2 if: DP value ≤ 0.5 X and D value> 0.5 X, X is the number of sub-elements.
c. Sector 3; strong driver- strongly dependent variables (linkage). The sub-elements that enter this sector must be studied carefully because the relationship between the elements is unstable. Any action on a sub-element will have an impact on other sub-elements and the effect of the feedback can amplify the impact. Sub-elements that enter sector 3 if: DP value> 0.5 X and D value> 0.5 X, X is the number of sub-elements.
d. Sector 4; strong driver-weak dependent variables (independent). The sub-elements that are included in this sector are the remaining parts of the system and are called independent variables. Sub-elements that enter sector 4 if: DP value> 0.5 X and D value ≤ 0.5 X, X is the number of sub-elements.

Results and Discussion

Elements of Stakeholders, Coastal Zone Management Institutions

The results of the Reachability Matrix (RM) analysis based on the test results on 13 sub-elements of stakeholders (institutional) show that the institution that plays a key role in the institutional analysis of Lore Lindu National Park management with interpretive structural modeling techniques is the Lore Lindu National Park Agency which is directly supported by the roles of regional agencies include the Central Sulawesi Provincial Bappeda, the Poso District Bappeda, the Sigi Regency Bappeda, the Donggala District Bappeda, the Central Sulawesi Provincial Environmental Agency and the Customary Figures/Customary Institutions/ Community Leaders. These results explain the importance of the role of the main stakeholders, the Lore Lindu National Park Agency and the Spatial Planning Agency, both the Central Sulawesi Provincial Government, the Sigi, Poso, and Donggala District Governments witnessed by traditional leaders/customary institutions/community leaders then consolidated together in achieving management of the Lore Lindu National Park into a sustainable national park area. The results of the ISM analysis are expected to become a standard institution in efforts to improve the management of the Lore Lindu National Park. The arrangement of the Reachability Matrix hierarchical structure can be presented in Table 3.

Table 1 : Final Structural self-interaction matrix in the element reachability matrix (RM)

Sub elemen ke-i	Sub elemen ke-j													Driven Power	Ranks
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13		
A1	1	1	1	1	1	1	1	1	1	1	1	1	1	13	1
A2	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
A3	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
A4	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
A5	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
A6	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
A7	0	0	0	1	0	0	1	0	1	0	0	0	0	3	6
A8	0	0	0	1	0	0	1	1	1	1	1	1	1	8	5
A9	0	0	0	0	0	0	1	0	1	0	1	0	0	3	6
A10	0	0	1	1	0	1	1	1	1	1	1	1	1	10	4
A11	0	1	1	0	1	1	1	1	1	1	1	1	1	11	3
A12	0	0	0	0	0	0	0	0	0	0	0	1	0	1	7
A13	0	1	1	1	1	1	1	1	1	1	1	1	1	12	2
Dependency	1	8	9	10	8	9	12	10	12	10	11	11	10		
Ranks	6	5	4	3	5	4	1	3	1	3	2	2	3		

The results of the analysis using the ISM method on the 13 stakeholder sub-elements (institutional) obtained the final reachability matrix as in Table 1.Based on this table, it can be seen that the sub-elements that have an important role in the management and protection of the national park are the Lore Lindu National Park Hall with government support. Locally, this is a key sub-element that is very useful in developing the management of the Lore Lindu National Park area.

The results of the sub-element matrix and the classification of the stakeholder (institutional) matrix analysis of the Lore Lindu National Park area can be presented in Figure 2.

No	Sub-element
A1	Balai Taman Nasional Lore Lindu
A2	Bappeda Kabupaten Poso
A3	Bappeda Kabupaten Sigi
A4	Bappeda Kabupaten Donggala
A5	Bappeda Provinsi Sulawesi Tengah
A6	Badan Lingkungan Hidup Daerah dan Kehutanan Sulawesi Tengah
A7	Pihak Swasta
A8	Pemerintah Desa/Pemerintah Kecamatan
A9	Perguruan Tinggi
A10	Forum Kemitraan Kawasan LLNP
A11	Forum DAS Provinsi Sulawesi Tengah
A12	Dinas Pariwisata Provinsi Sulawesi Tengah
A13	Tokoh Adat/Lembaga Adat/ Tokoh Masyarakat

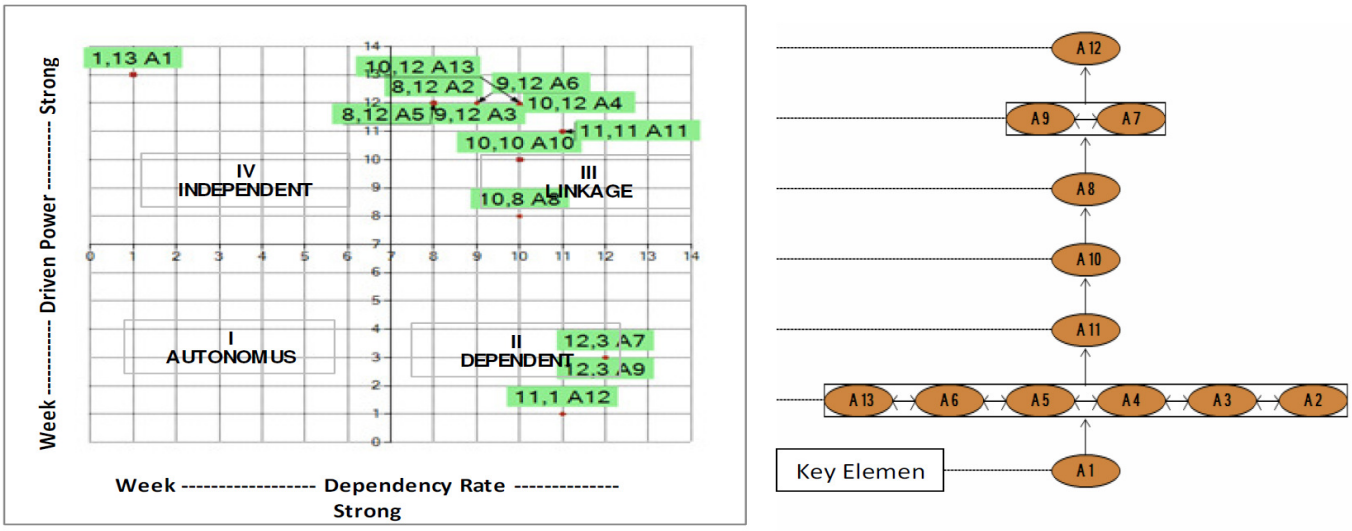

Fig. 2 : Model Matrix, SubElement, and Classification of Matric Analysis Calculation

The results of the matrix analysis show that the Sub-elements of Bappeda of Central Sulawesi Province, Bappeda of Poso Regency, Bappeda of Sigi Regency, Bappeda of Donggala Regency, Village / Local District Governments, Regional Environmental Agency of Central Sulawesi Province, LLNP Regional Partnership Forum, Customary Figures / Customary Institutions / Figures The community and the Central Sulawesi Provincial Watershed Forum are in the linkage sector, which means that these sub-elements of the linkage sector must be studied carefully in assessing success benchmarks in the institutional analysis of Lore Lindu National Park management. This is because these sub-elements will have an impact on others and the feedback of their effects can amplify that impact. The sub-elements of the Lore Lindu National Park area in the independent sector, where this sub-element has a great driving force in achieving institutional analysis in the management of the Lore Lindu National Park area.

Hierarchical Structure Model Diagram for the Sub-Element stakeholder (institutional) Based on the hierarchical structure, it can be seen that in addition to being a key institution in the Lore Lindu National Park management program, the Lore Lindu National Park (A1) is also a driving sub-element at the first level or a key element (highest) in the hierarchical structure. The role of each institution in the management of the Lore Lindu National Park must be following its hierarchy. Sub-elements that are at level 2 (two) that act as institutions that bridge the implementation of the management of the Lore Lindu national park in the research area include Bappeda Central Sulawesi Province, Bappeda Poso Regency, Bappeda Sigi Regency, Donggala Regency Bappeda, Regional Environmental Agency Central Sulawesi Province, and Traditional Leaders / Customary Institutions / Community Figures. Based on the results of the arrangement of a hierarchical structure in improving institutions and maintaining the condition of environmental imbalances in the national park area, efforts to improve institutions are needed (Ostrom, 2012; Yelin *et al.,* 2015; Nasir, 2016). This view explains that there are five dimensions in ensuring environmental management, namely social, economic, environmental, technological, and institutional aspects which must be an important factor in efforts to improve the sustainability of the national park area (Munawir *et al*., 2019; Zuhud, 2011; Rustiadi *et al*., 2003; Tietenberg and Lewis 2009).

Elements of Constraints in the Management of the LLNP Area

The results of the reachability matrix (RM) of the final element reachability matrix (RM) are presented in table 2. as follows :

Table 2 : Final Structural self-interaction matrix (SSIM) in the element reachability matrix (RM)

Sub elemen ke-i	Sub elemen ke-j												Driver Power	Ranks
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12		
C1	1	0	1	1	1	1	1	0	1	1	1	1	10	3
C2	1	1	1	1	1	1	1	1	1	1	1	1	12	1
C3	0	0	1	1	0	1	0	0	1	1	1	0	6	6
C4	0	0	1	1	0	1	0	0	1	1	1	0	6	6
C5	1	1	1	1	1	1	1	1	1	1	1	1	12	1
C6	1	1	0	0	1	1	1	1	1	1	1	0	9	4
C7	1	1	1	1	1	1	1	1	1	1	1	1	12	1
C8	1	1	1	1	0	1	1	1	1	1	1	1	11	2
C9	0	1	0	1	0	1	0	0	1	1	1	0	6	6
C10	1	0	1	0	1	1	0	0	1	1	1	0	7	5
C11	1	0	0	0	1	1	0	0	1	1	1	0	6	6
C12	0	0	1	1	1	1	1	1	1	1	1	1	10	3
Dependency	8	6	9	9	8	12	7	6	12	12	12	6		
Ranks	3	5	2	2	3	1	4	5	1	1	1	5		

The results of the Driven Power sub-elements address the key sub-elements of the obstacles faced in the management of the Lore Lindu National Park area in the study area, such as a massive illegal land clearing in LLNP, Weak Supervision and Control of Illegal Activities in LLNP, and Lack of Coordination and Integration of Resource Management. Nature between Stakeholders related to LLNP Management.

C1	Implementation and supervision of regulations related to the management of LLNP has not been optimal
C2	Massive illegal land clearing in LLNP
C3	Decreased biodiversity of Flora and Fauna in LLNP
C4	The transfer of land functions in LLNP has led to the decline in springs
C5	Weak supervision and control of illegal activities in LLNP
C6	Lack of Supporting Facilities and Infrastructure in LLNP
C7	Lack of Coordination and Integration of Natural Resource Management among Stakeholders related to LLNP Management
C8	Low awareness of communities around LLNP
C9	The vast coverage of the LLNP area
C10	Limited human resources at the LLNP Hall
C11	Lack of Budget and Program Allocation at the LLNP Hall
C12	Weak law enforcement

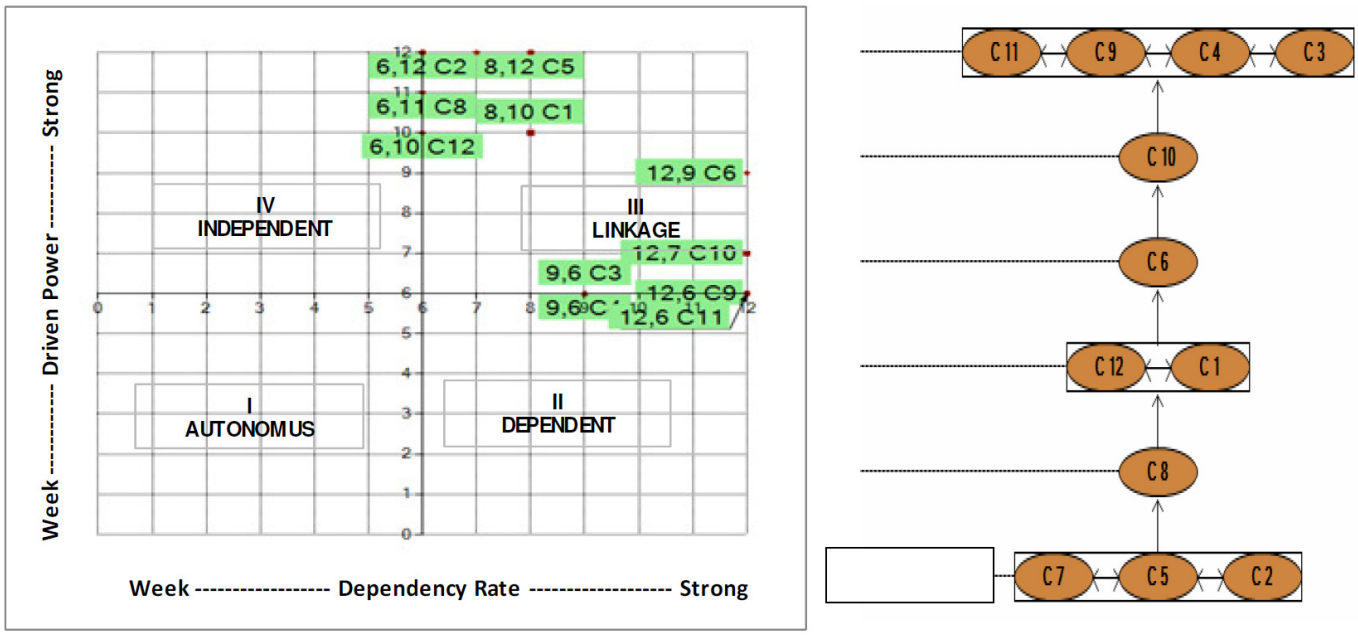

Fig. 3 : Model Matrix, Sub-element, and Calculation Classification of Matric Analysis

The results of the Sub-element Matrix and Matrix Classification show that the main constraints of the key elements in the analysis of the obstacles in the management of the Lore Lindu National Park area are the inadequate implementation and supervision of regulations related to LLNP management, massive illegal land clearing in LLNP, Decreasing Flora and Fauna Biodiversity in LLNP, weak supervision and Control of Illegal Activities in LLNP, Lack of Supporting Facilities and Infrastructure in LLNP, Lack of Coordination and Integrity of Natural Resource Management among Stakeholders related to LLNP Management, Low Public Awareness around LLNP, Limited Human Resources at the LLNP Hall, and Weak Law Enforcement are in the sector Linkage (Sector 3). The obstacles faced in the management of the Lore Lindu National Park area will be resolved in stages according to the levels and hierarchies. This means that the increased coordination and integration of Natural Resource Management among stakeholders related to LLNP management, massive illegal land clearing in LLNP, and weak supervision and control of illegal activities in LLNP which are supported by the availability of a detailed plan in the form of operational technical guidance will be able to overcome these obstacles. constraints that exist at level 1 (one). This shows that these three obstacles must be overcome in overcoming the main obstacles in the management of the Lore Lindu National Park.

Hierarchical Structure Model Diagram Sub Elements of constraints in the management of Lore Lindu National Park Sub key elements of massive illegal land clearing in LLNP, Weak Supervision and Control of Illegal Activities in LLNP, and Lack of Coordination and Integration of Natural Resource Management among Stakeholders related to LLNP Management. This result is in line with the research of Ahmad Jazuli (2017), in the area planning plan requires the implementation of law enforcement, in (Wulandari and Sumarti 2011) states that legislation is needed so that there is a collaborative spatial plan for data integration of national park areas to minimize potential conflicts between regions, between sectors, and between communities and governments (Schlager and Ostrrom, 1992; Scott, 2008).

Based on the constraints and participation of stakeholders, it is necessary to anticipate the institutions that are prepared to overcome the problems of managing the Lore

Lindu National Park area by carrying out real coordination in increasing the role of indigenous peoples as well as community leaders and managers of the national park hall to maintain the sustainability of the management of the national park area (Ostrom, 2012; Mulyono, 2014).

Conclusion

- The key elements of stakeholders and institutions in the management of the Lore Lindu National Park have an important role in the Lore Lindu National Park Hall in collaboration with the local government as well as traditional and community leaders.
- The key elements of the main obstacle to the management of LLNP which are the key elements are the massive illegal clearing of land in LLNP, Weak Supervision and Control of Illegal Activities in LLNP, and Lack of Coordination and Integration of Natural Resource Management among Stakeholders related to LLNP Management.
- The results of the Interpretative Structural Modeling (ISM) analysis are expected between stakeholders and ministerial agencies and local governments to guarantee environmental management partnerships for the sustainability of the Lore Lindu National Park not only for now but also for the future.

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