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Improving the depth and complexity of stakeholder deliberation using images: Experimental evidence from Indonesia

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ABSTRACT

In this study, we tested interventions to improve the depth and complexity of deliberation processes with rural aquaculture farmers in Indonesia facing collective action problems in governing water distribution. The field experiment was conducted in four aquaculture villages in Lombok, Indonesia, where farmers were actively involved in the co-management PITAP program to maintain irrigation canals. The intervention was a version of the Social-Ecological Systems Framework (SESF) translated into images that depicted the variables of the framework in the context of the case study. We hypothesized that the connected image-based SESF deliberation tool could facilitate more in-depth discussions on the complexities of social and ecological issues compared to baseline (no images) and control groups (images with no framework relationships). To gauge the farmers' intent to care for irrigation canals post-PITAP collectively, we employed the Reasoned Action Approach (RAA) from environmental psychology. Our experimental study revealed that employing the SESF as an image-based deliberation tool did not measurably improve the depth and complexity of the discussions within the context of the traditional aquaculture communities in Indonesia. Nevertheless, the data derived from the content of discussions indicates that employing the image-based tool results in different but important outcomes among the experimental groups with implications for a better understanding of context and culture where deliberation processes occur. We further reflected on our findings on the hierarchical societal relationships in the context of rural communities in Indonesia that influence the deliberation style and reception.

1. Introduction

Deliberation can alter individual mental models, social norms, and relationships within a group, thereby shifting the way collective action problems are addressed (Cundill and Rodela, 2012; Heller and Rao, 2015). In our study, we explore a shift from individualistic decision-making approaches to collaborative, community driven solutions for managing common resources like irrigation canals (Eriksson et al., 2019; Fazey et al., 2013; Ojha et al., 2019). This would involve a change in how resource users – in this case is aquaculture farmers – perceive their role within the social-ecological systems from acting based on individual interest to recognizing and valuing collective well-being (Hodge and Southorn, 2003). The key is not only the number of representatives of different types of stakeholders participating in deliberation but having the participation of the (morally, strategically, and pragmatically) relevant actors (Kujala et al., 2022). Equally important is their willingness to contribute in open exchange to support an interactive learning process with a willingness to revise prior beliefs about things such as shared governance problems (Barabas, 2004; Habermas, 1985; Healy, 2011). If properly instituted, deliberation can facilitate communicative processes between stakeholders that provide space to consider distributive justice for sustainable resource management (Baber, 2010). It can also contribute to democratic and fair decision-making (Parkins and Mitchell, 2005; Robertson and Choi, 2012). Thus there is an urgent need to design deliberation in collaborative governance such that it facilitates learning processes, knowledge

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exchange, and personal reflection to target sustainable changes (Rist et al., 2007).

Deliberation processes require structure and a systematic procedure to guide the process productively and include a variety of views in environmental decision-making (Renn, 2006). Structure is necessary to encourage procedural rationality and transparency for collaborative governance (Renn, 2006). Well-structured deliberation tools provide reasonable conditions to support deliberative processes (Hansson and Ekenberg, 2016) and open-up an avenue for participants to disclose their mental models for knowledge exchange (Gastil, 2018). With a structured format, deliberation provides equal opportunities for all participants to engage in discussion regardless of their background or education level (Beauvais and Baechtiger, 2016; Moscrop and Warren, 2016; Ryan et al., 2023). Deliberation also enhances civic participation to be active contributors to their communities (Bächtiger et al., 2018) and fosters a collective learning environment (Henly-Shepard et al., 2015).

While deliberative processes in environmental governance are sometimes led by researchers and at other times by local actors (Paramita et al., 2023a), a structured deliberation tool that facilitates knowledge co-production between researchers and non-researcher stakeholders is still limited (Galende-Sánchez and Sorman, 2021; Norström et al., 2020; Wyborn et al., 2019). This study aims to explore how such a tool, designed by researchers based on complex system frameworks but implemented in deliberations led by the actors in the field, is understood and applied in practice to address pressing collective action challenges in aquaculture governance settings.

1.1. Experimental research on deliberation

In the realm of environmental governance, creating spaces for deliberation often manifests in the form of focus group discussions. They are increasingly used as a research method to empirically examine perceptions, values, and opinions of stakeholders involved in decision-making processes (Paramita et al., 2023a; Sulkin and Simon, 2001). Despite efforts to enhance participatory processes, the current studies lack a comprehensive approach to developing a deliberation tool that can effectively bridge the communication gap between researchers and non-researcher stakeholders within the confines of a controlled experiment.

Controlled experimental studies in deliberation are essential to investigate the impacts of participatory and deliberative processes on the participants themselves (Fujitani et al., 2017). Controlled experimental settings can avoid the influence of other factors, such as the 'observer effect' (Franke and Kaul, 1978) and the 'social desirability effect' (Nunnally, 1967). Previous deliberative research has addressed the need to develop methods for deliberation (Falk-Andersson et al., 2015; Ranger et al., 2016), evaluate deliberation processes (Crawford et al., 2018; Koning et al., 2021), and evaluate deliberation outcomes (Blunkell, 2017; Harris et al., 2012). However, there are limited studies to compare the effects of deliberation on participants before and after deliberation.

A growing body of literature explores the use of visual aids such as maps, images, diagrams, and simulations in deliberation processes for environmental governance (Lynam et al., 2007; Metze, 2020; O'Neill et al., 2017; Rodríguez Estrada and Davis, 2015). Maps, for instance, have been widely used to represent spatial data, enabling stakeholders to visualize the geographic dimensions of environmental issues (Burdon et al., 2019; Glaas et al., 2020; Palomo et al., 2014). Images and diagrams have been employed to simplify complex systems and relationships, facilitating communication of abstract environmental concepts (Ison et al., 2024; Partelow et al., 2019; Vervoort et al., 2014). Similarly, simulations have been effective in engaging participants by illustrating potential future environmental scenarios (Hara et al., 2023; Planque et al., 2019; Poumadère et al., 2015; Sánchez-Jiménez et al., 2021). These visual tools have been applied for various purposes, such as enhancing knowledge sharing, fostering more inclusive participation, and improving the overall quality of deliberation in environmental governance.

This study is interested in using images as a deliberation tool because communication experts have argued that images can improve communication of complex concepts such as systems interactions between people and nature by aiding comprehension and the learning process (Dewan, 2015). Empirical studies have shown that images can be more persuasive than text and helpful in conveying complex concepts (Altinay, 2017; Gurney et al., 2019). Through images, researchers could identify or demonstrate social and ecological components related to the observed phenomenon (Liebenberg, 2009). For participants, images can serve as a starting point to discuss complex problems based on scientific frameworks of social-ecological knowledge (Patel et al., 2007). Consequently, incorporating an image-based deliberation tool can effectively complement traditional deliberation methods, enhancing the overall quality of the deliberation processes.

Our research aims to develop an image-based deliberation tool based on a scientific framework, the Social-Ecological Systems Framework (SESF) (McGinnis and Ostrom, 2014). The rationale for transforming the SESF into an image-based deliberation tool is grounded in its ability to provide a systematic and comprehensive understanding of the interrelated social and ecological factors affecting resource management (Hinkel et al., 2014; Partelow et al., 2019; Schlüter et al., 2014). The introduction of the SESF as an image-based deliberation tool requires communicating scientific concepts into accessible formats for non-researcher stakeholders. In our study, the SESF was presented in an accessible and culturally relevant way as an object to provide structure and facilitation, allowing researchers to remain background observers rather than leading or dominating the deliberation processes. The images derived from the SESF are presented as visual representations of the framework to understand how the structure and organization of the SESF variables influenced the depth and complexity of participants' deliberations. This study is designed in an experimental setting to test whether structuring the variables (treatment group) enhanced participants' ability to engage with the complexities of the social-ecological systems compared to unstructured variables (control group) and without any images (baseline group).

1.2. Case study to conduct a field experiment

Indonesia ranked among the leading global producers in aquaculture (FAO, 2020). Indonesia has potential for the aquaculture sector with a total area of 17.91 million Ha, which includes 2.8 million Ha of freshwater cultivation area (15.8%), 2.96 million Ha of brackish water cultivation area (16.5%), and 12.12 million Ha of marine cultivation area (67.7%) (KKP, 2020). The aquaculture sector is essential for Indonesia, both financially and nutritionally (Henriksson et al., 2019). However, aquaculture development in Indonesia encounters numerous social and environmental challenges (Henriksson et al., 2017).

The Ministry of Marine Affairs and Fisheries of Indonesia (MMAF) has created a Participatory Pond Irrigation Management (PITAP) program to improve the production of traditional aquaculture and salt farmers across Indonesia by motivating collective action (KKP, 2020; Paramita et al., 2023b). Aquaculture and salt farmers need to register as a community-based co-management group (POKLINA) to access funding from the PITAP program. The success indicators of the PITAP program are rehabilitated irrigation infrastructure for pond aquaculture and community participation to maintain the irrigation systems collectively after the program ends (KKP, 2020). In PITAP, deliberation plays a crucial role in ensuring the inclusive participation of water users in irrigation canal rehabilitations. A POKLINA group, empowered with decision-making authority, determines the irrigation canals requiring rehabilitation, the suitable timeframe for rehabilitation, participant selection, and cost estimation through deliberation processes.

The field experiment was conducted in four aquaculture villages in the West and East Lombok regions where the PITAP program was

implemented in 2020 and 2021 (Fig. 1). Data were collected from August 2021 until January 2022. The participants of this experiment were recruited by purposive sampling: aquaculture and salt farmers who participated in the PITAP program in Sekotong, Sambelia, and Jerowaru Villages. In the study locations, women do not involve in aquaculture and PITAP program. Hence, the experiment was conducted only with men to discuss about the implementation of PITAP program and its influence on collective action among them. We used Lembar village as the location for pilot testing to avoid interference between piloting subjects and experimental subjects included in the analysis (Gerber and Green, 2012). The data collection was carried out with a health and ethical protocol to mitigate the spread of COVID-19. No cases of COVID-19 were reported among participants and interviewees during or right after the data collection period.

1.3. Theories to measure the outcomes of experimental deliberation

We designed a psychometric questionnaire using the Reasoned Action Approach (RAA) by Fishbein and Ajzen (2011) to measure psychological factors related to people's intentions and behavior to test the hypotheses with the assumed effects of participation (Fujitani et al., 2017). According to the RAA, the participants' changes in behavior can be brought about by changing their intentions (Fishbein and Ajzen, 2011). The five components of the RAA consist of (1) attitude towards behavior, (2) injunctive norms, (3) descriptive norms, (4) perceived behavioral control, and (5) behavioral intention. Attitude toward behavior is defined as the degree to which the execution of the behavior is positively or negatively evaluated. An increase in participant's positive attitudes toward collective action indicates a more positive evaluation of the behavior of maintaining irrigation canals. Injunctive norms are the perception of what others think an individual should do. An increase in participant's injunctive norms indicates they perceive greater social pressure from other people to engage in maintaining irrigation canals. Descriptive norms are the individual's perception of what others do. An increase in participant's descriptive norms indicates individuals perceive the desired behavior is regularly being performed by others. Perceived behavioral control is the perceived capability to perform the behavior under their control successfully. An increase in participant's perceived behavioral control indicates more confident feeling to contribute to the desired behavior. Behavioral intention is an individual's subjective likelihood or perception that they will perform a specific behavior, and is a strong predictor of actual behavior (Klöckner, 2013). An increase in behavioral intention indicates a stronger commitment to take part in the desired behavior after the deliberation. In this study, we examine each of these components individually, rather than relying on a cumulative measure, to understand how these distinct elements influence participants' intentions and behaviors.

1.4. Research objective and hypotheses

The objective of this study was to assess the effectiveness of the image-based deliberation tool in enhancing depth and complexity during discussion. This study employed a scientific framework, the Social-Ecological Systems Framework (SESF) (McGinnis and Ostrom, 2014) as a template for designing an image-based deliberation tool that captured the complexity and interaction of system variables in environmental governance settings (Partelow, 2018; Partelow et al., 2019) (Fig. 2).

The SESF consists of first and second-tier variables nested in a multi-tier organizational structure. The first-tier variables consist of Resource Systems (RS), Resource Units (RU), Governance Systems (GS), Actors (A), Interactions (I), Outcomes (O), Social, Economic, Political Settings (S), and Related Ecosystems (ECO). The second-tier variables are components of each first-tier variable that act as a checklist to diagnose collective action and sustainability problems in social-ecological systems (McGinnis and Ostrom, 2014; Partelow, 2018). The SESF is used as a discussion guideline oriented towards systems thinking and the link between social and ecological systems as a lens to reflect on collective action problems among non-researcher participants (McGinnis and Ostrom, 2014; Partelow, 2019). On the one hand, the SESF as an image based deliberation tool can narrow down the scope of discussion according to the logic of collective action theory, as the framework was based on (Partelow, 2018; Thiel et al., 2015). On the other hand, the SESF provides a comprehensive list of social and ecological variables

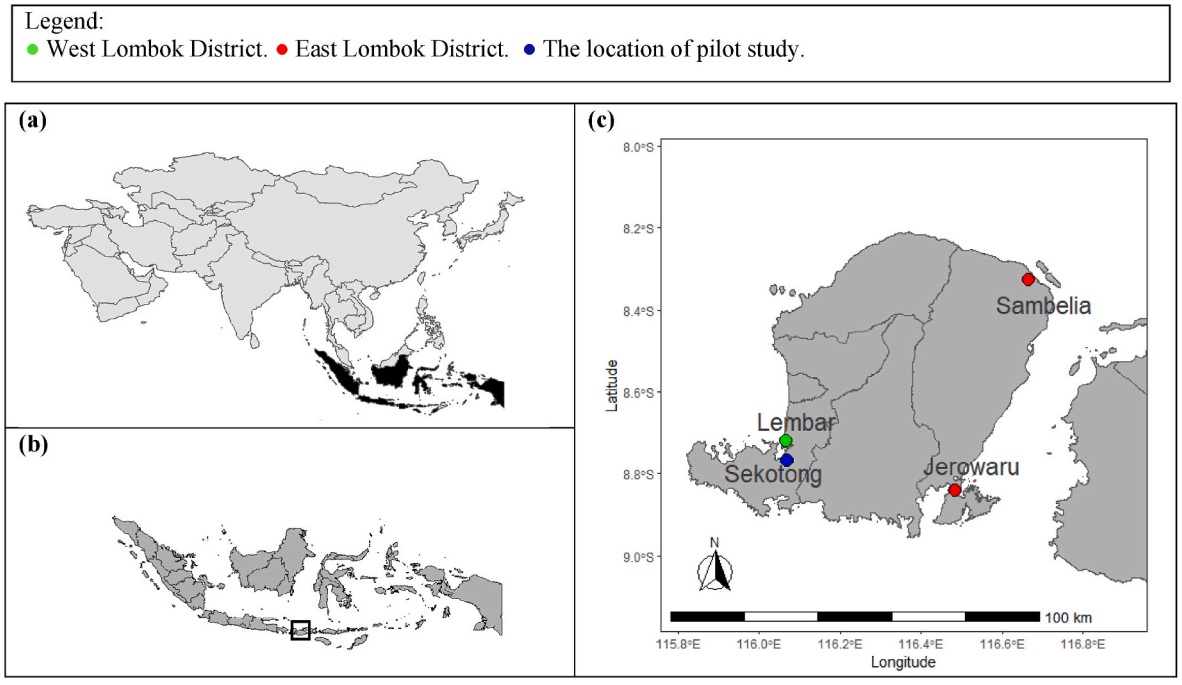

Fig. 1. The location of the case studies. The experimental study was conducted in Sekotong in the West Lombok district (marked by a blue dot) and in East Lombok, Jerowaru, and Sambelia (marked by red dots). Lembar was chosen as the location for piloting (marked by a green dot).

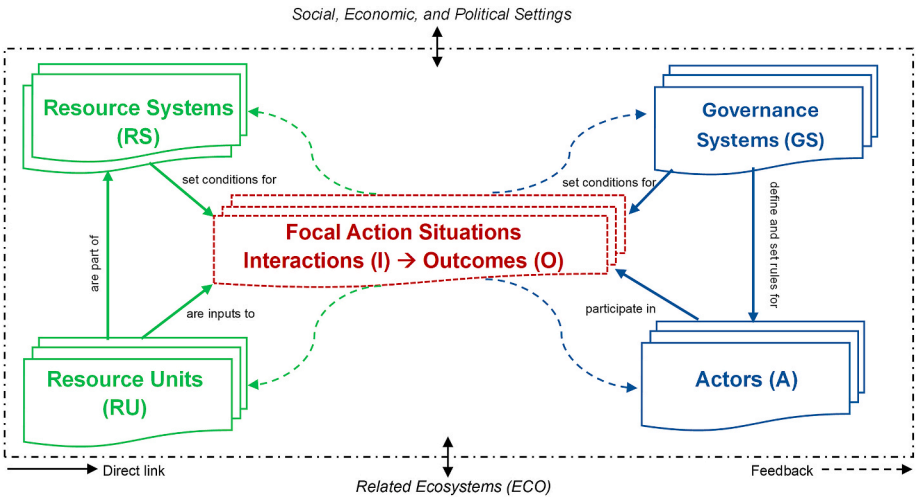

Fig. 2. The social-ecological systems framework (McGinnis and Ostrom, 2014).

that can measure whether the discussion was conducted in more depth and complexity among non-researcher participants.

Participants were categorized into three experimental groups: baseline, control, and treatment. The baseline consisted of discussion groups without the use of any deliberation tool. Baseline group allows us to establish a reference point for the 'neutral' effects of deliberation after excluding other factors. The control included discussion groups with an image-based deliberation tool in unstructured SESF variables, enabling us to analyze the effects of guided deliberation in general. The treatment comprises discussion groups with image-based deliberation and structured SESF variables, allowing us to analyze the effects of guided deliberation on participants' ability to engage in a structured discussion involving the interconnection of social and ecological systems.

We developed three hypotheses to test if our image-based deliberation tool - based on the SESF by McGinnis and Ostrom (2014) - can enhance depth and complexity during discussion. (I) We assume the structured image-based deliberation tool enriches discussions by incorporating a broad range of social and ecological variables and their interactions that are relevant to understanding collective action problems. (II) After the deliberation process, we assume that there will be an increase in scores of psychometric constructs related to the RAA among participants with the structured image-based deliberation tool. (III) Lastly, we assume that individual participants with the structured image-based deliberation tool are predicted to positively self-evaluate the deliberative activity with regards to depth, complexity, personal reflection, and knowledge exchange. All hypotheses are tested in an experimental framework, comparing treatment groups to control groups (unstructured images) and baseline groups (no structuring tool or images).

2. Methods

2.1. Exploratory phase and instrument development

Data collection included semi-structured interviews based on the SESF second-tier variables to diagnose the governance problems and the implementation of the PITAP program in four aquaculture villages. We interviewed the representatives of the ministerial government, provincial government, local government, and local stakeholders such as NGOs, community leaders, aquaculture association members, and local researchers to understand important social and ecological variables that influence aquaculture system. Using this understanding, we selected the key variables to explain the interactions of social and ecological systems of the study locations and transformed them into images. The list of interviews is available in Appendix 1, while interview guidelines are in Appendix 2A and 2B. The rationality to transform several variables as images in the deliberation tool is presented in Appendix 3.

2.2. Preparation of experimental materials and piloting

The preparation of experimental materials involved three main steps: selecting images to represent the SESF variables, developing psychometric questionnaires, and conducting pilot studies. The data obtained during the exploratory stage were used to determine which variables from the SESF are presented as images and to design the structure of the psychometrics questionnaires. We selected the images from *flaticon.com* with a paid subscription to access and use the images representing selected SESF variables. The experiment materials and procedures were piloted with eight deliberation groups in Lembar village to make sure the farmers understand the images to guide discussions and undergone several revisions based on the feedback from farmers. We chose Lembar village as the location for the pilot study to minimize the risk of answers being influenced between the pilot participants and those in the actual experiment. The images were selected to represent the concepts in the framework in a way that makes it easy for participants to interpret what the images mean. The final SESF image-based deliberation in English is shown in Fig. 3, while the Bahasa Indonesia version can be seen in Appendix 4A and 4B.

2.3. Field experiment

The recruitment process used purposive sampling: only farmers involved in the PITAP program were eligible to participate in our experimental deliberation study. On average, the experimental deliberation process took around 1 h per experimental group. The majority of the experimental deliberation was conducted with a prior appointment with three farmers for one deliberation group in the *Berugaq*[1] around 7 p.m.–9 p.m. when they were relaxing with other farmers that live close to each other. Only a few experimental deliberations were conducted in the afternoon because gathering three aquaculture farmers simultaneously during the day was impractical.

2.3.1. Pre-deliberation

This field experiment used block random assignments. Participants

[1] Berugaq is a traditional building of Sasak Lombok tribe. It has a gazebo-like shape, the roof is made of dried coconut leaves, and the floor is made of woven dried bamboo. It replaces the function of living room to accept guests or a meeting point.

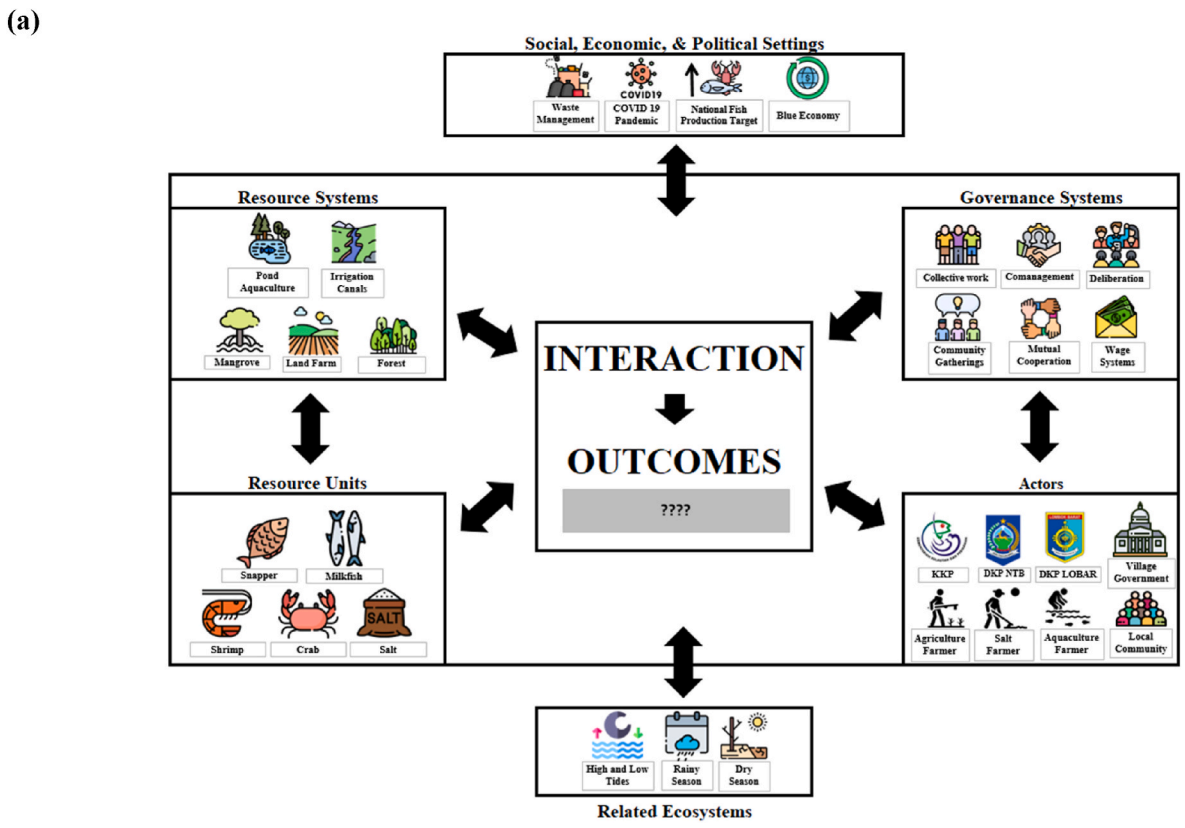

Fig. 3. Image-based deliberation tool for (a) treatment and (b) control groups. Baseline groups did not receive any visual aid deliberation materials.

were partitioned into experimental groups (or blocks) that consisted of three people, then random assignment occurred within each experimental group (Gerber and Green, 2012). A random assignment procedure was conducted by pulling one out of three cards that represented baseline, control, and treatment before meeting the participants.

Before the start of the experiment, the researcher asked the participants for verbal informed consent to participate in the study and permission to record audio of the deliberation process. The researcher asked each individual farmer's demographic profile questionnaire (Appendix 5) and the psychometrics before-deliberation questionnaire (Appendix 6). Pre-deliberation sessions lasted an average of 20 min.

2.3.2. Deliberation process

All experimental groups were given the same two question cards for discussions: a) what are the benefits of the PITAP program? b) what are the social and ecological challenges to achieve these benefits? Before the start of deliberation process, the first author explained the procedures for all groups but only explained the SESF concepts to control and treatment groups. Baseline groups were asked to start the discussion without any image-based deliberation material. Control groups were given an unstructured image-based SESF deliberation tool. Meanwhile, treatment groups received a structured image-based SESF deliberation tool and the overview of the SESF by the researchers in relation to the meaning of the arrows, interactions, and outcomes. The first author left a voice recorder, observed the deliberation process from a distance, and took field notes. Each experimental group had the freedom to decide the length of their discussion and use the local language (*Sasak* or Bahasa Indonesia). The deliberation session lasted an average of 25 min with the shortest session at 17 min and the longest at 36 min.

All recordings from experimental groups were transcribed with the help of local research assistants to Bahasa Indonesia with *Sasak* recordings being translated on the fly. The transcriptions were then translated to English by the first author. In total, we conducted 23 groups of experimental deliberations. Three participants in each experimental group were chosen to foster discussion and interaction among participants. The PITAP program was conducted by around 30 farmers in each village. The number of experimental groups and their proportions are summarized in Table 1.

2.3.3. Post-deliberation

After the deliberation process, individuals from all experimental groups were asked to fill out the psychometric after-questionnaire (Appendix 6) and the deliberation evaluation questionnaire (Appendix 7). The post-deliberation session lasted an average of 15 min.

2.4. Data analysis

2.4.1. Depth, complexity, and holistic thinking (group-level analysis)

The transcript data from each group discussion were analyzed using a content analysis approach focused on thematic areas and word frequencies (Carley, 1990). To organize our data into thematic areas, we utilized the SESF as a coding template by referring to the variables of the SESF (McGinnis and Ostrom, 2014). The first and second author collaborated in the coding process, employing a consensus approach that relied on iterative discussions and refining comprehension of the data. Three separate coding rounds were conducted. After each round, the codes were compared and discrepancies were addressed through discussion, aiming to achieve an 80% similarity threshold as recommended in related work (Roller, 2019).

Depth was calculated by the total number of second-tier variables within each first-tier of the SESF mentioned during the deliberation process. Complexity was calculated by the average of second-tier of the SESF variables to each first-tier variable. Then, the relative proportion or evenness of the content of the discussion was compared between first-

(b)

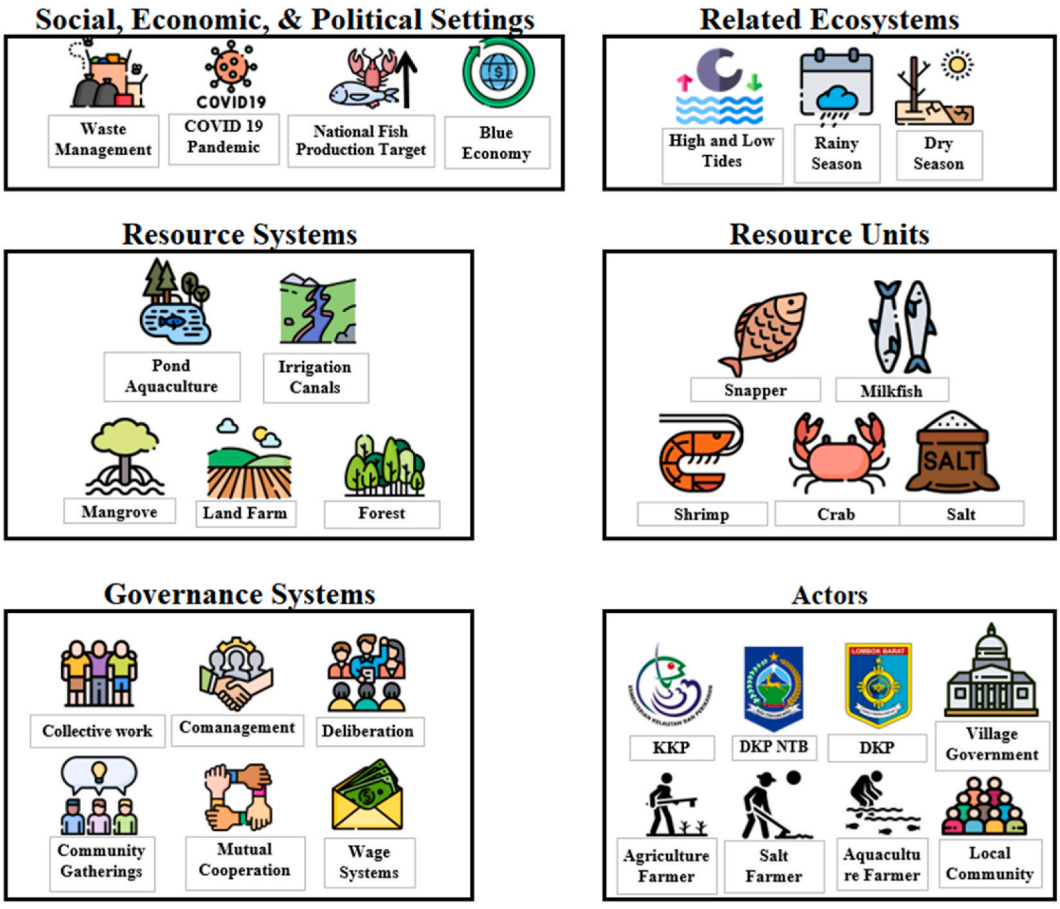

Fig. 3. (*continued*).

Table 1
Experimental groups.

	Baseline (Without any visual aid)	Control (Unstructured image-based SESF)	Treatment (Structured image-based SESF)
Sekotong	1	4	5
Jerowaru	1	2	2
Sambelia	1	4	3
Total groups	3	10	10
Total participants	9	30	30

tier variables across experimental groups. The holistic of the discussion was calculated by the average number of variables of each group. In analyzing holistic thinking, we weighed data by the average number of the SESF variables mentioned in a particular group, so that each is measured in comparison to their own experimental group average.

2.4.2. *Impact of deliberation on individuals (individual level analysis)*

The RAA and deliberation evaluation questionnaires were measured using a 5-point Likert response format ranging from −2 (strongly disagree) to 2 (strongly agree). In the pilot study, the scale −2 to 2 was better for our study participants to express their agreement or disagreement than the conventional 1 to 5 scale. It is due to cultural and contextual factors related to more straightforward interpretation where negative values indicate disagreement, zero for neutral, and positive values indicate agreement among farmers in Lombok. The RAA construct relationships were tested with exploratory factor analysis and reliability analysis (Cronbach's alpha) for internal consistency in respondent's answers (Cronbach, 1951).

We hypothesized that the means of the psychometric constructs after deliberation among the treatment groups would be higher compared to control and baseline groups. The analytical framework used with this experimental design is before-after impact-control (BACI) or difference in differences. This allows for statistical detection and calculation of differences before and after the intervention between baseline, control and treatment groups (Fujitani et al., 2017; Partelow et al., 2019; Stewart-Oaten et al., 1986).

Linear mixed effects models (LMM) were applied to describe the relationships between a response variable and explanatory variables that consist of fixed and random effects (Magezi, 2015; Zuur, 2019). Fixed effects are the variables of interest in the study while random effects are 'nuisance' variables one wants to generalize over (Magezi, 2015; Singmann and Kellen, 2019). Within participant factors in LMM address the possibility that the distribution of ratings will be different for individual participants, which can result in pseudo-replication (Hesselmann, 2018). Pseudo-replication occurs when the use of inferential statistics to analyze treatment effects are applied for example where treatments or replicates are not statistically independent (Hurlbert, 1984). LMM supports analysis of data by partitioning the different sources of variability to generate correct inferences (Chaves, 2010).

In this study, LMM analysis is applied to analyze RAA variables (as a response variable) with explanatory variables of fixed effects: before-after, control-impact, and the interaction between 'before-after' and 'control-impact; and random effects: villages and individual participants. Incorporating individual participants as a random effect acknowledges individual variability or within-participants factors, and

autocorrelation within the same individual across repeated measurements (Verbeke et al., 1997). Meanwhile, the village as another random effect accounts for clustering effects and unobserved heterogeneity that influenced the differences between villages (Zeger and Karim, 1991).

In addition, we conducted Principal Component Analysis (PCA) to transform high-dimensional data into a new coordinate system, where the data's variability is maximized along the axes called principal components (PC) (Demšar et al., 2013). The main objective of PCA in this study was to better describe the differences related to the contents of discussions by mapping the distribution of the SESF variables mentioned based on groups. To analyze PCA, the content of the group discussions was coded into first-tier SESF variables. Therefore, PCA was used to depict patterns in the variations across the groups based on the content of discussions.

The statistical programming environment in R software (http://cran.r-project.org) was used, for details see Appendix 8.

3. Result

3.1. Depth, complexity, and holistic thinking (group-level analysis)

We conducted one-way ANOVA tests across experimental groups to determine the amount of variability and to analyze whether the variability is greater between groups than within groups (Table 2). One-way ANOVA tests conducted among experimental groups revealed that the variable 'Actors' showed a trend toward significance with $F(2, 20) = 2.6507$, p-value $= 0.095$ ($p < 0.1$), although it did not reach the conventional threshold for statistical significance ($p < 0.05$). Meanwhile, Tukey's HSD tests for multiple comparisons found that the treatment groups discussed more about the variable 'Actors' compared to control groups at p-value $= 0.079$, ($p < 0.1$). There was no statistical difference reported between baseline, control, and treatment groups for complexity of discussion and holistic thinking.

We present the distinctions in the content of discussion through radar plots among different groups in Fig. 4. Each spoke represents one of first-tier SESF variables and each point on the spoke reflects the frequency of deliberation content from different groups (indicated by color). When comparing the groups, baseline groups discussed more first-tier SESF variables than control and treatment.

Table 2
ANOVA on Depth, Complexity, and Holistic Thinking using the SESF Variables. Mean and standard errors (in parentheses). Tukey's HSD test is indicated with $^{a/ab/b}$. Groups with the same letter are significantly different from each other, while groups with different letters are statistically different. Signif. codes: . p < 0 .1, *p < 0.05, **p < 0.01, ***p < 0.001.

SESF Variables	Baseline	Control	Treatment	P-value (ANOVA)
Number of groups	(3)	(10)	(10)	
Resource systems (RS)	4.67 (1.68)	6.4 (1.91)	5.9 (1.91)	0.668
Resource units (RU)	6.33 (1.77)	4.6 (2.02)	4.1 (2.02)	0.552
Actors (A)	3 (1.46)^{ab}	2 (1.67)^{b}	4.6 (1.67)^{a}	**0.095.**
Governance systems (GS)	3.33 (1.81)	2.7 (2.07)	4.5 (2.07)	0.450
Interactions (I)	3.67 (0.78)	2 (0.89)	2 (0.89)	0.165
Outcomes (O)	5 (1.17)	3.6 (1.34)	3.7 (1.34)	0.568
Social, Economic, and Political Settings (SEP)	0 (0)	0 (0)	0 (0)	0.000
Related Ecosystem (ECO)	3 (0.81)	1.5 (0.92)	1.5 (0.92)	0.246
Complexity	29 (6.38)	22.8 (7.27)	26.3 (7.27)	0.636
Holistic thinking - threshold 1	0.88 (0.06)	0.8 (0.07)	0.8 (0.07)	0.541
Holistic thinking - threshold 2	0.83 (0.11)	0.65 (0.13)	0.69 (0.13)	0.364
Holistic thinking - threshold 3	0.58 (0.14)	0.44 (0.15)	0.51 (0.15)	0.593

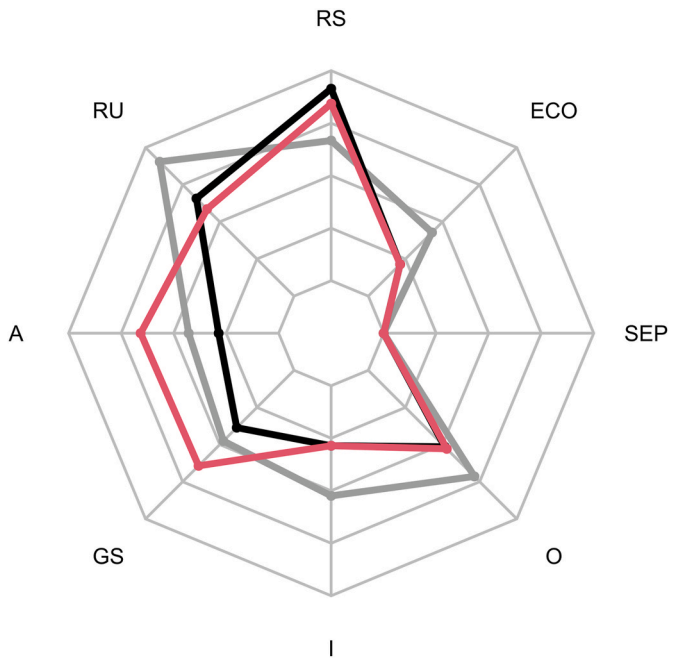

Fig. 4. Radar plot for the SESF variables.

Our PCA analysis revealed distinct patterns in how groups engaged with the SESF variables, highlighting key correlations between discussion topics. We conducted PCA to visualize similarities and differences between different groups (Fig. 5). The first and second PC were selected out of six PCs which represent 70.7 % of the variance due to the eigenvalues greater than 1 (>1.0). PC1 (50.1%) explains the most significant amount of variance in the data, and PC2 (20.6%), explains the second most significant amount of variance. As participants discussed the variable 'Actors', they tended to discuss more about 'Governance Systems' (very strong correlation). As participants discussed 'Outcomes', they tended to discuss more about 'Resource Systems' (very strong correlation). PCA analysis by experimental groups showed that control groups had fewer mentions of the SESF variables, especially related to 'Actors' and 'Governance Systems' compared to other groups.

3.2. Impact of deliberation on individuals (individual level analysis)

Overall, the general trend of the RAA figures based on mean constructs shows a decreasing pattern after intervention across experimental groups. Some increasing values after intervention are reported only among the control groups related to 'Attitudes toward behavior' and the baseline groups related to 'Injunctive norms'. Important to note that based on the figures, the baseline groups considered 'Behavior intention' to maintain the irrigation canals to be quite high before the intervention but went down drastically, while the control groups did not change and the treatment groups went down slightly. Constructs by experimental groups are visualized in Fig. 6. The reliability of the items to represent the constructs of the psychometric questionnaire is presented in Appendix 9.

The analysis indicates that 'Descriptive norms' in treatment groups showed a near-significant trend toward change compared to baseline groups, potentially influenced by perceptions of community leadership. 'Descriptive norms' of treatment groups showed a trend toward significance with $\beta = 0.306$, $SE = 0.180$, p-value 0.098 ($p < 0.1$) compared to baseline, although this result does not meet the conventional threshold for statistical significance ($p < 0.05$). The quotes below are examples of

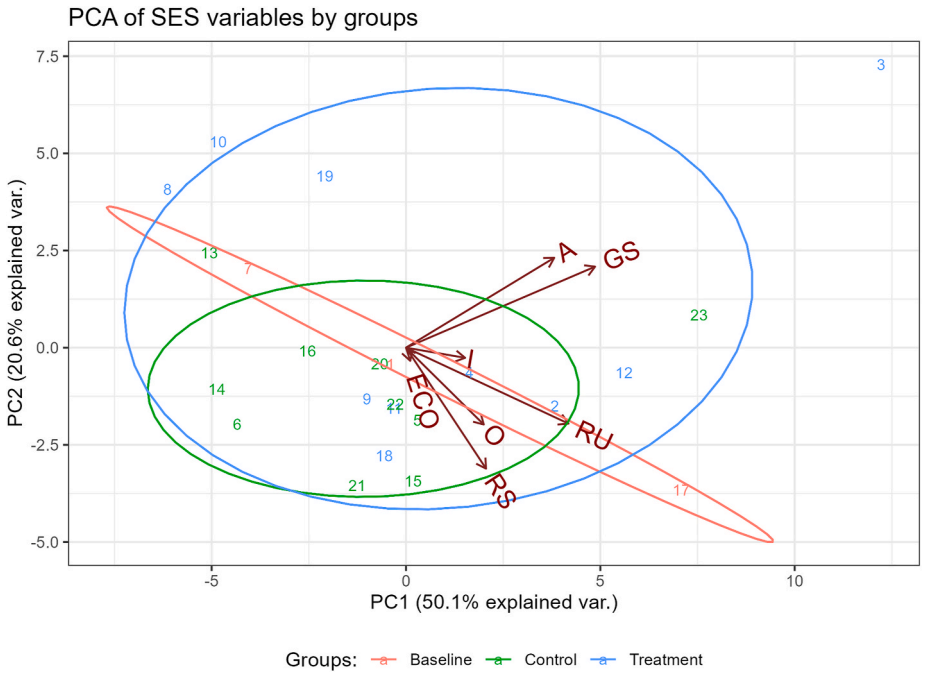

Fig. 5. PCA Analysis for the SESF variables.

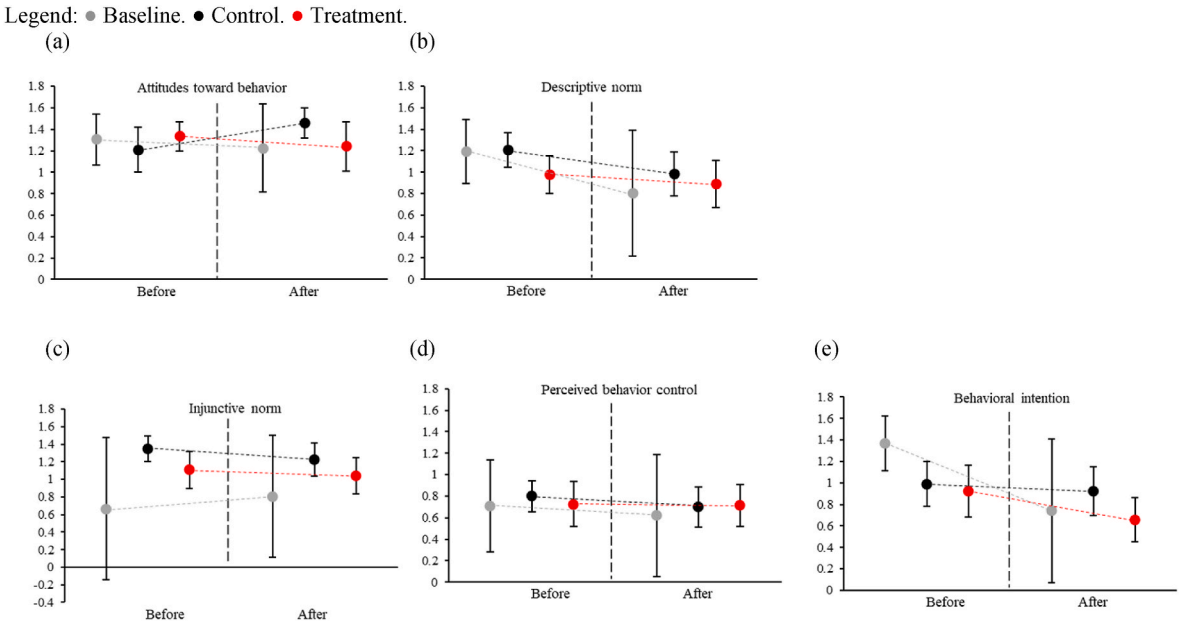

Fig. 6. Mean construct by experimental groups.

deliberation transcripts that show treatment groups had more discussion concerning the positive evaluation of the community leader (A5 – Leadership) that might influence 'Descriptive norms' not likely to change after deliberation. Contradictory, baseline groups discussed about negative evaluation of the community leader that might influence decreasing 'Descriptive norms' after deliberation. The results of the LMM to analyze RAA constructs comparing baseline and treatment groups are reported in Appendix 10.

> "Our Gotong-Royong (collective action) depends on the community leader, people in the community regardless of age never complained to do it, it has never been a problem to work together as far as I know." – Treatment group 4

> "In this village, if the local community requires Gotong-Royong (collective action), we just simply need to tell the community leader, then he will coordinate it." – Treatment group 3

> "We do have routine maintenance (irrigation canals), but it only happens when the community leader command us to do so, if he does not say anything, we would not take any action." – Baseline group 1

The analysis indicates that 'Behavioral intention' significantly increased among control groups compared to baseline, likely due to discussions on economic incentives associated with the PITAP program. 'Behavioral intention' of the control groups was statistically significant and *positive* at $\beta = 0.563$, SE = 0.241, p-value 0.025 ($p < 0.05$) compared to baseline. The quotes below are examples of deliberation transcripts

that show control groups discussed more about economic incentives (I5 – Incentive activities) associated with participating in the PITAP program. Particularly, it is emphasized that providing economic incentives is crucial when non-farmers are involved in taking care of the irrigation canals. Consequently, 'Behavior intention' among control groups for collective action for the next PITAP program was not likely to change after deliberation. Meanwhile, baseline groups had negative evaluation toward the diversity of livelihoods that caused decreasing 'Behavior intention' after deliberation. The results of the LMM to analyze RAA constructs comparing baseline and control groups are reported in Appendix 10.

> "Last time I joined (PITAP program) because I got paid, I asked my relatives to participate as well. During pandemic, you cannot just rely on (aquaculture) ponds for livelihood." – Control group 2

> "So far only among POKLINA members we do the maintenance for irrigation canals without payment, once we involved non-farmers, we need to pay them" Control group 4

> "The challenge arises due to some of us are engaged in other side jobs like agriculture and construction labor, which means they are not always present at the pond aquaculture. Consequently, when we need them to repair irrigation canals, they may not be available" – Baseline group 1

The analysis indicates that 'Attitudes toward behavior' significantly decreased in treatment groups compared to control groups, likely due to ownership status of the ponds. Excluding baseline groups, we tested differences between treatment and control with the LMM (Appendix 11). Within this model, only 'Attitudes toward behavior' of the treatment groups was statistically significant and *negative* at $\beta = -0.342$, SE = 0.156, p-value 0.032 ($p < 0.05$) compared to control. The quotes below are examples of FGD transcript that show control groups discussed more about the problems related to ownership of the pond (GS4 – Property right systems) which led to farmers' dependency on pond owners for decision-making. Consequently, 'Attitude toward behavior' among treatment groups was lower after deliberation. Meanwhile, control groups discussed more on the benefits of PITAP (RU1 – Resource unit mobility) that caused increasing 'Attitude toward behavior' after deliberation.

> "Even though the irrigation canals are good (well maintained), however, the ponds do not belong to people around here, the boss (pond owner) needs to pay the cost of rehabilitation because he is the one who gets the benefit the most." – Treatment group 1

> "It all depends on the owner of the ponds, if they agree to rehabilitate, as an aquaculture labor, I will rehabilitate the irrigation canals because the owner paid me to do so" – Treatment group 2

> "Before, only those who have capitals they can rent or buy water pump to access water, after PITAP program we can access water regularly from irrigation canals." – Control group 3

3.3. Self-reported deliberation evaluation (individual-level analysis)

The analysis indicates a significant difference in 'Depth and Complexity' between control and treatment groups, suggesting a more nuanced engagement in one group over the other. Control and treatment groups were compared with a Welch 2 sample T-test and results are reported in Table 3. Differences between control and treatment groups are significant for 'Depth and Complexity' at p-value = 0.017 ($p < 0.05$). Summary statistics and reliability analysis of self-reported deliberation evaluation are presented in Appendix 12.

4. Discussion

Our experiment in deliberation does not yield clear evidence to support hypotheses I, II, and III due to a lack of statistical significance. While it is well-known that results that do not pass a particular p-threshold face a publication bias, our results nonetheless offer both qualitative and quantitative insights that contribute meaningfully to the literature on deliberation (Franco et al., 2014). The image-based SESF deliberation tool did not measurably improve the depth and complexity of the discussions in the context of traditional and rural communities in Indonesia. However, visualization data based on the content of discussions suggests that image-based SESF deliberation generates distinct outcomes across experimental groups. To elucidate these findings and their implications, we further reflect on political culture in the implementation of deliberation in Indonesia.

Table 3
T-test on deliberation evaluation by structured (control) and unstructured (treatment)
Signif. codes: . $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Construct	Control (n = 10)	Treatment (n = 10)	P-value (Welch 2 sample T-test)
Depth and Complexity	1.367 (0.086)	1.033 (0.104)	**0.017** *
Personal Reflection	1.35 (0.102)	1.233 (0.109)	0.438
Knowledge Exchange	1.3 (0.078)	1.35 (0.093)	0.683

According to our first hypothesis, we assumed the treatment groups would incorporate a broad range of social and ecological variables in their discussions of collective action problems. However, hypothesis I was not substantiated because only the "Actor" variable in treatment groups was significantly higher than control. This indicates that the SESF – when converted to images - has the potential to encourage farmers to discuss the varying degree of participation of different actors in addressing collective action problems.

The second hypothesis, we assumed the treatment groups would show an increase in the RAA scores. However, hypothesis II was not substantiated because only three constructs of RAA were reported statistically significant. First, treatment groups were reported significantly lower than control in 'Attitude toward behavior' of RAA. From the deliberation transcripts, it shows that treatment groups discussed more about the absence of pond ownership (SG4 – Property right systems). This caused negative evaluation of participants' assessment on *Gotong-Royong* in practice, as reflected by lower 'Attitudes toward behavior' after deliberation. Second, treatment groups were reported a trend toward significance compared to the baseline in 'Descriptive norms'. From the deliberation transcripts, it shows that treatment groups discussed more about the role of community leader (A5 – Leadership). This caused positive evaluation of participants' perception of what others do to implement *Gotong-Royong*, as reflected by a higher 'Descriptive norm' after deliberation. Third, control groups were reported as statistically significant compared to the treatment in 'Behavioral intention'. From the FGD transcripts, it shows that control groups discussed more about the economic incentives from PITAP program (I5 – Incentive activities). This could be interpreted as representing an increased likelihood to participate in the PITAP program in the future, as reflected by higher 'Behavior intention' after deliberation.

Finally, the third hypothesis, we assumed that participants in the treatment groups would positively evaluate the deliberation process. However, hypothesis III was not substantiated because only participants from the control groups evaluated the deliberation process as providing depth and complexity compared to treatment groups. This is an interesting finding because it indicates that participants in this study evaluated the deliberation tool with disconnected concepts of the SESF better than with connected ones. We interpret this as participants in this study having a deeper and more complex discussion when a guided tool presents one topic or concept at a time. The connected SESF (i.e., with arrows linking the many concepts) was perhaps too complex or may have

caused confusion over how the participants viewed the system themselves. Having only single concepts may have been more suitable for catalyzing discussion among participants because it primed concepts they knew about but did not suggest relations to other concepts, which allowed participants to better convey their own perceived system connections to that concept. From a scientific perspective, this could lead to the generation of new insights about how local stakeholders perceive and interact with the system. Such an approach could facilitate the co-production of knowledge, where both scientific and local understandings are integrated, creating more context-specific and actionable governance strategies.

We further analyzed the differences in the content of the discussion using the visualization of the radar plot (Fig. 4A). In the comparison among experimental groups: treatment groups discussed more related to "Actors" and "Governance Systems", control groups discussed slightly more over "Resource Systems", while baseline groups discussed more over "Resource Units", "Related Ecosystems", "Interactions", and "Outcomes". Similarly, the visualization of the PCA (Fig. 5) showed that the bubble plots for treatment and control groups shared similar patterns and shapes indicating similarities in the content of the discussion. However, baseline groups showed a different pattern and shape. Even though treatment groups were reported as statistically significant related to "Actor" compared to other groups, baseline groups had more variety and different types of the SESF variables mentioned during discussion compared to treatment and control. This indicates that context matters in which the discussions across all groups took place, and that control and treatment groups discussed different types of content guided by the interventions, which can be an important reflection for thinking about how intervention activities can steer deliberation processes consciously towards specific content.

In light of the results, we reflected on Indonesia's history of decades under centralized and authoritarian rule which might influence its deliberation style. Although decentralization systems have been introduced since 1998 to allow local levels of government to have decision-making power, a centralized system of patronage decision-making remains intact, especially in traditional or rural societies in Indonesia (Antlöv and Wetterberg, 2011). As opposed to non-hierarchical or egalitarian, social relationships based on hierarchy demand different attitudes and behaviors in interactions with people in various social positions (van Wietmarschen, 2022). Differences in the demographics profiles of participants across groups may have caused social hierarchy based on their age, education or literacy, and ownership of the ponds (Appendix 13). In addition, when one does not have the skill for deliberation, people tend to endorse hierarchy by suggesting that people with higher social status lead the discussion and make decisions (Van Berkel et al., 2015). An Indonesian study by Taufiq et al. (2022) strengthened this argument by indicating that deliberation is not a space for transferring knowledge because of power domination in a hierarchical society. This is reflected in our self-evaluation questionnaire findings (Appendix 12) that indicates, "This exercise was useful to understand the perspectives of other people" that tends to receive less positive evaluations. We interpret this result as participants did not feel comfortable expressing their opinions, so the other people know that the discussion will not tell the actual perspective of other participants. Recognizing how inequality influences power dynamics and discussion in the context of traditional rural societies in Indonesia, a moderator or facilitator is important to ensure equal participation and encourage rural communities to speak more during the deliberation process that aim for knowledge exchange.

While our study did not support the initial hypotheses, it offers valuable insights into the potential limitations of the SESF within the specific context of aquaculture governance. The results suggest that the SESF though versatile in many other environmental governance contexts (Nagel and Partelow, 2022; Partelow, 2018; Thiel et al., 2015), may not always be the most effective tool for catalyzing stakeholder deliberation among non-researcher stakeholders in certain environmental governance contexts. In our study, aquaculture farmers faced challenges in using the structured SEF to engage in discussions that provide a comprehensive perspective on social-ecological systems. The results of our control group suggest that the SESF and similar scientific frameworks could still be valuable for deliberation by providing distinct elements that help participants better understand the interrelations within complex systems like SES.

The psychometric analysis based on RAA before and after deliberation yielded diverse results contingent upon the content of discussions according to the SESF variables, which varied across experimental groups. The SESF, functioning as a guided tool, stimulated comprehensive discussions, resulting in both positive and negative evaluations of the prevailing collective action mechanisms. Positive evaluation in discussion can increase motivation to participate in the future deliberations, enhance the legitimacy of collective decisions, and lower decision ambivalence (Stromer-Galley and Muhlberger, 2009). While, negative evaluations in discussion could potentially demoralized and demobilized, they also provided constructive input and awareness among participants to improve collective action (Fishkin, 2018). Having taken into account previous studies with our sample size calculation (Partelow et al., 2019), and with recognition that with large enough sample size any arbitrary difference become statistically significant, further studies with larger sample sizes could help clarify the observations in this study.

5. Conclusion

Our experimental study revealed that employing the SESF as an image-based deliberation tool did not measurably improve the depth and complexity of the discussions within the context of the traditional aquaculture communities in Indonesia. However, the study added useful insights on methodological design and intervention efficacy. The data indicates that employing image-based SESF deliberation leads to observably different outcomes between the experimental groups. Despite insufficient evidence to support our hypotheses, we contend that this experimental study holds value as it contributes to our understanding of the use of scientific intervention to guide the deliberation process among non-researcher stakeholders, where our findings lead to substantial learning and methodological improvement. In the comparison content of discussion across experimental groups, there is an indication with statistically significant that the image-based SESF deliberation tool facilitates participants to discuss more "Actors". However, the groups without any visual aid (baseline) had a greater variety of variables mentioned in the discussions than the other groups. This indicates that context in which discussions take place matters and that a guided deliberation tool can intentionally steer deliberation processes towards specific content. We analyzed the results using the literature related to local deliberation norms in Indonesia. Hierarchical societal relationships are an important factor influencing our experimental study. However, analyzing the inequality power among participants in the deliberation process is beyond the scope of our study. In this experimental study, the SESF has shown adaptability application within aquaculture governance and has potential to be applied in diverse environmental governance contexts. Incremental introduction of the SESF, with sequential discussion of its key elements, may facilitate a more comprehensive understanding of social-ecological systems among non-researcher stakeholders. The SESF can facilitate discussions that yield both positive and negative evaluations of existing collective action mechanism. We suggest for development programs that focus on rural communities in Indonesia to involve a moderator in the deliberation process to address power inequality among participants.

CRediT authorship contribution statement

Adiska Octa Paramita: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis,

Conceptualization. **Stefan Partelow:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Nurliah Buhari:** Project administration, Formal analysis. **Marie Fujitani:** Writing – review & editing, Visualization, Supervision, Methodology, Formal analysis, Conceptualization.

Consent to participate

This study ensures that, the consent to participate is maintained and no contradiction.

Ethical approval

This study ensures that, the ethnical approval is maintained and no ethnical contradiction.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ocecoaman.2024.107503.

Data availability

Data will be made available on request.

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