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Linking responsible leadership and sustainable performance through the mediation of maintenance management implementation and agile organization

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Abstract: Under the concept of independent maintenance proposed by the Meteorology, Climatology, and Geophysics Agency (BMKG) for operational equipment, a thorough analysis of its management processes is necessary. Leadership involvement at various levels can affect maintenance outcomes, impacting sustainability. This research creates a thinking model that connects responsible leadership (RL) with sustainable performance (SP) through agile organization (AO) mediation and maintenance management implementation (MMI) in the management of leading operations equipment. The method used was a survey of 366 respondents who were BMKG employees, and explanatory analysis was analyzed based on descriptive statistical analysis using SmartPLS. The research results show that the third hypothesis proposed is acceptable, and the two mediator variables are partial mediation. The discussion of the study results shows some theoretical and practical implications for achieving the goals of SP, where organizations should encourage RL behavior that can implement current practices regarding AO and MMI. The test results show that AO and MMI have a significant role as mediators in encouraging the influence of RL on SP. This study is the first step in examining the relationship of RL to SP using AO and MMI mediation. Furthermore, this model can be developed and analyzed in other sectors or fields to increase knowledge.

Keywords: sustainable performance; responsible leadership; maintenance management implementation; agile organization

1. Introduction

In the last ten years, there has been an increase in the incidence of geohydro-meteorological disasters, such as earthquakes and extreme weather that trigger hydro-meteorological hazards. Disaster events annually become a record, as well as data on how disasters have significantly impacted human survival over time (Yulianto et al., 2021). In the last ten years, in general, the number of disasters that occurred in Indonesia tends to increase. Indonesia's highest number of disaster events occurred in 2020, with 5003 cases. The number of victims of this natural disaster itself certainly depends on the level of damage caused by the disaster, as well as the number of frequencies of natural disasters (Husein, 2016). If we look further, climate change is one of the most significant factors causing this disaster.

Under intense climate change, sustainability is a real challenge for society and businesses (Amui et al., 2017). This study explores the factors analyzed that impact sustainable performance (SP) in government organizations for maintenance activities. Saihi et al. (2023) conducted a causal relationship research involving 207 respondents with a model design that affects SP through efficient resource allocation. Sustainable

performance refers to the company's performance in society, the economy, and the environment in the era of sustainable development (Argandoña and von Weltzien Hoivik, 2009). Sustainability is one of the most integral factors today, and there is a need to adapt to achieve long-term sustainability (Mustafa and Abbas, 2021). The triple bottom line (TBL), introduced by sustainability expert Elkington (1998), offers a holistic framework for defining organizational sustainability. Therefore, many studies studying sustainable performance in organizations use TBL as their conceptual basis and cite Elkington's proposal as their conceptual reference (Cinelli et al., 2014; Jabbour et al., 2019).

Recognizing the pivotal role of leaders within organizations is paramount as they navigate the intricate web of stakeholder interests by securing and deploying vital resources, crafting strategic plans, and pinpointing the most efficacious routes to sustainable development (Cheema et al., 2020; Iqbal and Ahmad, 2021). The worldwide movement toward sustainability is another example of such a transition (Smith and Sharicz, 2011). Conventional leadership was only focused on profit, and traditional conceptions of development, which persisted until the 1970s, saw development as a component of economic growth (Tomislav, 2018). Today's leaders must balance the three pillars of sustainable development's interrelated environmental, social, and economic objectives (Correia, 2019). Xuecheng et al. (2022) show that an organization's sustainable performance (SP) is its overall performance for all stakeholders and across all domains, measured by environmental, social, and economic factors. However, with the increasing recognition of the importance of sustainability, leaders now need to consider a broader range of factors beyond economic growth.

Until now, there is still very little research linking SP with the role of RL in the government sector (Khanam, 2023; Székely and Knirsch, 2005). Previous research shows that other factors influence SP, mediating and moderating the relationship between RL and SP. Especially in the scope of maintenance management in the government sector, it is not easy to find literature that discusses things outside of manufacturing. In the government environment, RL plays a vital role and influences fast changes; this shows that a leadership style can bring about agile principles. Leadership is critical and crucial in promoting psychological safety for employees and, of course, helps to move the organization to become agile (Edmondson and Lei, 2014). Worley and Jules (2020) say that agile organizations value learning over punishing failure, and top management makes decisions quickly to generate new data. Subsequent decisions that accelerate testing, innovation, and implementation are more informed so that they linearly impact sustainable organizations.

This research discusses practically the impact or influence of responsive leadership, agile organization, and adaptation of maintenance management variables on maintenance activities to become maintenance management implementation (MMI) on SP as measured by three factors, namely the triple bottom line (TBL). However, there still needs to be research on sustainability performance maintenance in the government sector's meteorology, climatology, or geophysics organizations. Research in the previous literature was conducted on industry, manufacturing, and factories related to production, so gaps need to be explored when using sustainability models in government, such as Meteorology, Climatology and Geophysics Agency

(BMKG) in Indonesia. Gaps in previous research provide an opportunity to apply and combine several theories presented as practical proof of concept for this research.

Based on Law Number 31 of 2009, the BMKG is a government institution tasked with meteorology, climatology, and geophysics, disseminating geo-hydrometeorological information. In order to support and carry out this task, BMKG has a vision, namely, establishing a BMKG that is dependable, responsive, and capable of supporting community safety and the success of national development and playing an active role at the international level. To realize this vision, BMKG requires observation equipment, communication channel information flow, and database facilities. The facility must function adequately to produce accurate data for dissemination. The disseminated data comes from the Main Operational Equipment (Aloptama) of BMKG, which is spread throughout Indonesia. Concerning Aloptama, BMKG has the authority to establish technical standards for equipment related to aviation, maritime, air quality, and geophysical meteorological services. BMKG and geo-hydrometeorological disasters are closely related; based on Law Number 31 of 2009, Aloptama BMKG spread throughout Indonesia supports the need to analyze various existing disasters.

Currently, many Aloptama owned by BMKG still need to cover monitoring points for weather, climate, earthquake, and tsunami data throughout Indonesia. The number of Aloptama has doubled in the last ten years, reaching 2671 devices in 2022. This equipment includes the fields of meteorology, climatology, geophysics, communication network infrastructure, and database infrastructure. The increase in the number of Aloptama certainly requires periodic maintenance and repair. The role of BMKG technician employees is needed to maintain Aloptama, which has been installed to support the availability of precise and accurate BMKG data that can be used as a basis for geo-hydrometeorological disaster studies. These technicians are the backbone of operational equipment maintenance, ensuring Aloptama's functionality within BMKG's operations.

Furthermore, Aloptama's effective management is closely tied to the leadership policies and styles implemented within BMKG. BMKG has one head office, five regional hall offices, and 180 units spread throughout Indonesia, with varying responsibilities for managing Aloptama under the authority of each top-level manager. Based on this, Rubel et al. (2021) demonstrated that an organization needs to dynamically attain high performance in both societal and financial aspects to increase sustainable performance. This can be achieved through fostering a sense of responsibility, mutual learning, and norms to encourage voluntary environmental behavior in employees, as well as by adopting an appropriate leadership style (Fatmawatie and Endri, 2022; Liao and Zhang, 2020; Marlapa et al., 2024; Pureza and Lee, 2020; Tariq et al., 2020). The leadership style observed and considered in this study is responsible leadership (RL) as a trigger and booster for the sustainable performance of Aloptama BMKG maintenance activities. This can support and add to findings on using responsible leadership styles in government organizations where related research has yet to be conducted nationally or globally. The essential qualities of transformational, servant, and authentic leadership are all found in responsible leadership (Hapsari et al., 2021; Taştan and Davoudi, 2019). Riyanto et al. (2021) show a positive and significant influence between responsible leadership and

sustainable performance, so in the sustainable development goals, organizations must first encourage responsible leadership behavior. Top-level management can promote responsible leadership practices within the maintenance scope by articulating the organization's vision and mission. Employee attitudes will shift, and the information provided will help them meet long-term performance targets.

Aloptama's reliability is inseparable from the "good maintenance" management process that organization employees must carry out by realizing good maintenance management. Implementing correct and consistent systems, infrastructure, processes, and procedures, as well as maintenance, can minimize losses that occur so that operations become more stable (Mobley, 2008). Some previous literature has discussed how maintenance management can have good implications for companies (Akinradewo et al., 2023; Haryadi and Juliane, 2022; Jain et al., 2016; Lazakis et al., 2010; Pai and Rane, 2014), but there has been no related research conducted in a multinational manner in government institutions similar to BMKG. Based on SE MENPANRB number 390 of 2019, the Minister of State Apparatus Empowerment and Bureaucratic Reform followed up on the president's direction in terms of simplifying the bureaucracy by transferring the administrative positions of echelons III, IV, and V to functional positions. Bureaucracy simplification aims to develop a professional, dynamic, and adaptable bureaucracy to enhance performance and efficiency and promote public access to government services. This strategic step is a fundamental change made by the government in transitioning traditional organizations with a pyramid structure to agile organization (AO). Agility is a valuable asset that enables firms to quickly execute changes, test potential responses, and adjust to environmental changes (Miceli et al., 2021). One form of accelerating bureaucratic reform at BMKG to support maintenance activities is agile decision-making, which can cut bureaucracy and speed up the Aloptama maintenance process.

The concept designed by Rahim and Ullah Shah (2020) is the primary reference in developing a research model that fills the summary by combining concepts tested practically through questionnaires. Although previous research has investigated each of the variables outlined in the section above, apparent research gaps need to be explored further. Previous research still needs to be minimally studied by government agencies engaged in policy fields related to meteorology, climatology, and geophysics. Previous research focuses on specific aspects of responsible leadership or sustainable performance. However, it rarely integrates these two concepts with other variables that mediate the relationship comprehensively. Of the many studies discussed, a conceptual framework model needs to consider these four variables in one research model, so this is quite a large gap and is utilized in this research. This research is expected to significantly contribute to the existing literature and provide a deeper understanding of the relationships between RL, SP, AO, and MMI by highlighting this gap.

2. Literature review

2.1. Theoretical support

After conducting theoretical deepening related to sustainability theory to be applied in organizational maintenance, the TBL indicators were considered sufficient

to represent the concept of desire in the concept of self-maintenance at BMKG. Using the triple bottom line (TBL) indicator to represent the sustainability concept at BMKG is relevant and reasonable. BMKG is a government organization that operates in environmental monitoring and social services. BMKG, still paying attention to economic principles in planning the state budget, shows that the TBL approach holistically covers the operational impacts of BMKG in three main aspects: economic, social, and environmental. This allows BMKG to ensure long-term sustainability in environmental monitoring, social services to the community, and monitoring the organization's economic conditions by BMKG's mission and vision and government operational principles. Additionally, maintenance governance requires calculations related to economic, social, and environmental aspects summarized in the triple bottom line to achieve sustainable performance.

In line with this, responsible leadership (RL) emerges as a focal point in contemporary leadership literature (Maak and Pless, 2006; Suryatni et al., 2023). It is described as the skill and art of creating, fostering, and upholding trustworthy connections with various stakeholders inside and outside the organization and organizing conscientious actions to realize a significant and jointly owned business vision (Maak, 2007). Legitimacy, stakeholder trust, relationships, social capital, ethical culture, social entrepreneurship, performance, attitudes and cognition, motivation, job satisfaction, effects on followers (Voegtlin et al., 2012), leader effectiveness and team effectiveness (Megheirkouni, 2019) are just a few of the significant outcomes that RL is linked to (Doh and Quigley, 2014; Pless and Maak, 2011). Given that RL is a social-relational and ethical phenomenon that occurs in social interactions, a responsible leader can influence the attitudes and behaviors of his followers (Pless and Maak, 2011). Based on the literature study, the author considers indicators of organizational culture, human resource practices, and managerial support as factors that measure the influence of RL on maintenance management.

These factors play a crucial role in shaping an organization's management strategy, which can be defined as a high-level, flexible plan that oversees the organization's innovation and development initiatives (Wahyuni et al., 2022). A management implementation strategy is a high-level plan to supply the organization with the managerial implementation knowledge needed to implement its vision and objectives. For the scope of this research, the goal to be achieved is an optimal maintenance practice, so a formulation that can support management maintenance implementation is needed. Several studies show how implementing a well-implemented maintenance management system can reduce the annual maintenance budget by 10%–30% (Azadi et al., 2011). Maintenance management drastically changes manufacturing performance in India (Jain et al., 2016). Based on previous research conducted by Garg and Deshmukh (2006) and the question-and-answer process with maintenance managerial practitioners at the organization, this study considered indicators of maintenance techniques, maintenance performance measurement, and maintenance policies to implement MMI activities or practices to optimize costs, workload, and other resources and indirectly affect ongoing performance.

In parallel, the concept of agile organization (AO) underscores the importance of

adaptability in response to dynamic business environments. As Sanchez and Nagi (2001) emphasized, AO signifies an organization's strategic ability to adapt swiftly to turbulent external and internal changes. This adaptability places AO within the category of organizations capable of promptly responding to shifts in the internal and external organizational landscape while seizing emerging opportunities (Walter, 2021). Menezes et al. (2021) wrote six measurement indicators from AO: digital mindset, collaboration, adaptability, innovation, customer benefit, and speed of decision-making. They showed promising results and were interconnected with RL. These indicators are considered for review of their application to the maintenance process of Aoptama BMKG.

2.2. Responsible leadership and sustainable performance

Berkan et al. (2021) and Das et al. (2019) have shown a substantial correlation between leadership and the elements supporting social, financial, and environmental conduct. However, other factors, such as their followers' abilities and attitudes, the business's environment and culture, and other contextual factors, affect its effectiveness (Gosling and Grodecki, 2020; Mulyana et al., 2022). Leaders who maintain moral standards in line with the ethical culture of the organization can encourage employees' intentions to support the environment and to act in an environmentally conscious manner in the future, which can lead to increased sustainable performance (Akbar et al., 2024; Chang et al., 2020; Xuecheng et al., 2022). While it is well-established that RL impacts all aspects of organizational performance, more empirical research must be conducted on the relationship between RL and an organization's long-term success (Jawaad and Zafar, 2020). RL was observed to significantly affect sustainable performance by analyzing questionnaire results conducted in the public organization sector of one of Pakistan's provinces (Raziq and Wiesner, 2016). Based on these studies, the author developed these findings with application in the BMKG sector, especially in Aoptama maintenance. Considering the above, the following hypotheses are thus proposed:

H₁: Responsible leadership has a positive impact on sustainable performance.

2.3. Mediating role of maintenance management implementation

Liao and Zhang (2020) show that three indicators of responsible leadership (relationship building, relational governance, and sharing orientation) positively affect incremental environmental innovation, and relational governance and sharing orientation affect radical environmental innovation. This shows that responsible leaders will affect the management's performance. Continuous maintenance management needs to be considered by the chief technician as a maintenance actor to achieve sustainable performance. Maintenance performance measurement efforts were carried out by Parida and Kumar (2009) and Swanson and Dans (2000), where the problem of the boundary between maintenance productivity and performance measurement is structured by measuring maintenance performance to find a maintenance productivity index, linking maintenance strategy with performance; from high performance to high productivity, and the role of maintenance in increasing the productivity and profitability of their respective companies, it can be stated that:

H₂: Maintenance management implementation positively mediates the relationship between responsible leadership and sustainable performance.

2.4. Mediating role of an agile organization

Joiner (2019) argues that leadership is central to creating AO. He suggests that leaders develop proactive practices in leading organizational change, leading teams, and holding essential conversations. Petermann and Zacher (2021) suggest that leadership plays a significant role in initiating collaboration between teams and departments. Leaders also play an essential role in empowering employees and creating an agile culture. Varshney (2020) shows that agile human resources in SMEs require collaborative, performance-oriented, and self-focused team leadership with interchangeable roles and responsibilities.

RL can facilitate AO by emphasizing stakeholder interaction (Maak, 2007), influencing flexibility and participation, and ensuring exchanges between leaders and stakeholders (Doh and Quigley, 2014). To build relationships with maintenance activities, which sometimes have contradictory and rapidly changing goals, an adaptable and flexible organizational order is needed (Setiawati et al., 2022; Varshney, 2020), demonstrating the ability to react to turbulent and changing environments (Storme et al., 2020), can solve everyday problems, can learn to respond to new market demands, and can function efficiently under pressure (Haryadi and Juliane, 2022). Based on the literature previously described regarding the significant influence of RL mediated by various factors on SP, researchers consider AO to be a mediator that indirectly affects SP. Therefore, we can hypothesize that:

H₃: Agile organization positively mediates the relationship between Responsible leadership and Sustainable performance.

3. Research method

3.1. Conceptual model

The variables were measured using a five-point Likert scale, with “strongly disagrees 1/5” and “strongly agrees 5/5.” This model proposes a relationship between four interconnected variable constructions, as shown in **Figure 1**.

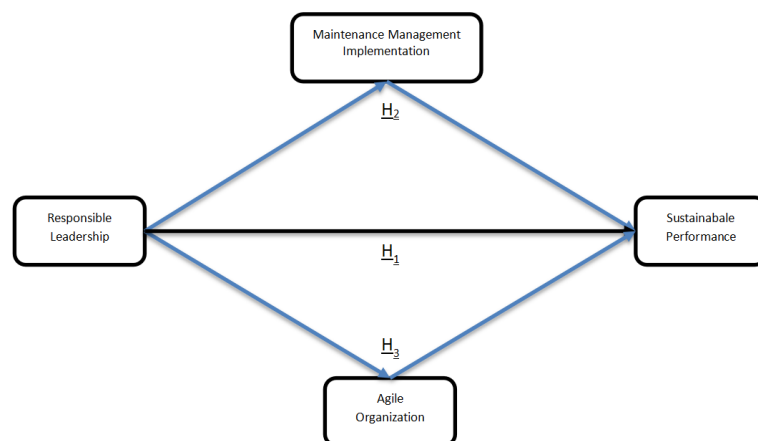


Figure 1. The research model proposed by the researcher.

3.2. Sample and procedure

The population in this study amounted to 598 units, which are all units relevant to the context of analysis related to SP. Regarding maintenance management, the head of central supervises the head of regions; then below that is the head of units (UPT), and there are team leaders. This leadership hierarchy plays a vital role in the implementation and governance of Aloptama maintenance, and leadership is measured by hetero-perception based on these levels. Employee measures the RL from the team leader; a level above, the team leader measures the RL from the head of the unit, then the head of the unit measures the RL from the head of central/head of regional, and finally, the head of central/the regional head measures RL from top-level management as the highest person responsible for the performance of the BMKG Aloptama. Based on this, the sampling method used was Stratified Random Sampling. The data was classified into several subgroups (strata) based on the characteristics of the respondents' positions. The sample was randomly selected to obtain 366 respondents, according to a proportional sample based on strata, and calculations with a margin of error of 4% were used.

3.3. Analytical strategy

The data analysis method used in this study is a descriptive statistical analysis method that combines explanatory, descriptive, and quantitative. The Partial Least Square-Structural Equation Modeling (PLS-SEM) approach was used to explain the relationship between the variables studied, so an explanatory research method was chosen to process the data. PLS programs confirm the existence of various types of structures for latent variables, test the compatibility and accuracy of the model based on empirical data observations, and test the cause-and-effect relationships between the factors observed in the model. The analysis technique used in this study is inferential statistics, which are procedural statistics that allow general conclusions to be drawn from the processed data. Testing the questionnaire results is divided into three parts: testing the measurement model (outer model), structural model (inner model), and hypotheses.

4. Results

Based on the questionnaire distribution to respondents, the characteristics of respondents can be known and grouped by gender, age, position, last education, and length of service according to **Table 1** below.

Table 1. Demographic characteristics of respondents.

No	Demographics	<i>N</i>	%
Gender			
1	Male	306	83.6%
2	Female	60	16.4%
	Total	366	100.0%

Table 1. (Continued).

No	Demographics	N	%
Age/generation (years)			
1	21–25 years (Gen Z)	41	11.2%
2	26–40 years (Gen Y)	175	47.8%
3	41–58 years (Gen X)	150	41.0%
	Total	366	100.0%
Positions			
1	Head of central/head of regional	4	1.1%
2	Head of units	75	20.5%
3	Team leaders/coordinators	40	10.9%
4	Technician employees	247	67.5%
	Total	366	100.0%
Experience			
1	<1 year	14	3.8%
2	1–3 years	26	7.1%
3	3–5 years	37	10.1%
4	5–10 years	64	17.5%
5	>10 years	225	61.5%
	Total	366	100.0%
Education			
1	DI—DIII formal/Teknik	35	9.6%
2	Bachelors	250	68.3%
3	Master	77	21.0%
4	Doctor	4	1.1%
	Total	366	100.0%

(Source: data processed, 2023).

Based on **Table 1** above, male respondents related to Aloptama constitute the majority of 306 people (83.6%) and female respondents as many as 60 people (16.4%). Generation Y, aged 26–40, became the most significant population as respondents in the study, namely 175 people (47.8%), and the least, generation Z with 41 people (11.2%). The classification based on positions is dominated by technical employees, totaling 247 people (67.5%). Then, in the second position are respondents with the position of Head of Units, totaling 75 people (20.5%). The head of units is the executor related to Aloptama maintenance management and has a crucial role in the ongoing maintenance activities. Based on experience, it was dominated by employees who had worked at BMKG for >10 years, with as many as 225 respondents (61.5%). Finally, demographics based on the last education of respondents are still dominated by bachelor’s graduates, totaling 250 employees (68.3%). Respondents who still need to be at the bachelor’s level are only 9.6%, thus showing that BMKG employees who manage Aloptama have a pretty good standard of education. The results of outer model testing in this study can be seen in **Table 2** below.

Table 2. Outer model result of research (Source: data processed, 2023).

Variable	Items	Indicator	Dimension	Factor loading	VIF	AVE	α	CR	Information
Responsible leadership (RL)/(X)	RL.1	Organizational ethics	Organizational culture	0.753	1.699	0.596	0.830	0.880	Valid & reliable
	RL.2	Organizational response		0.783	1.781				
	RL.3	Organizational performance assessment	Human resource practices	0.733	1.499				
	RL.4	Leaders support employees	Managerial support	0.791	2.083				
	RL.5	Leaders develop employee capacity.		0.798	2.132				
Maintenance management implementation (MMI)/(Z1)	MMI.1	Preventive maintenance	Maintenance techniques	0.620	1.173	0.603	0.774	0.857	Valid & reliable
	MMI.2	Effect of repair effectiveness	Maintenance Performance measurement	0.842	2.020				
	MMI.3	Maintenance integration	Maintenance policies	0.786	1.762				
	MMI.4	Maintenance concepts		0.838	1.871				
Agile organization (AO) (Y2)	AO.1	Customer centric	Digital mindset	0.761	1.881	0.609	0.892	0.916	Valid & reliable
	AO.2	Governance	Collaboration	0.796	2.294				
	AO.3	Administration		0.769	2.154				
	AO.4	Personal flexibility	Adaptability	0.728	1.742				
	AO.5	Utilization of the latest technology	Innovation	0.793	2.194				
	AO.6	Speed in product development		0.830	2.478				
	AO.7	Integration of ideas		Speed of decision making	0.780				
Sustainable performance (SP)/(Y)	SP.1	Quality	Economic	0.743	1.616	0.539	0.783	0.852	Valid & reliable
	SP.2	Productivity		0.758	1.613				
	SP.3	Effectivity		0.792	1.602				
	SP.4	Trust	Social	0.780	1.671				
	SP.5	Reduced environmentally damaging	Environmental	0.578	1.230				

Note(s): VIF = Variance inflation factors, AVE = Average variance extracted, α = Cronbach's alpha, CR = Composite reliability.

According to **Table 2**, all factor values are above the acceptable range of 0.5, and the composite reliability is higher than 0.80, indicating that each item has an adequate level of reliability (Hair et al., 2010). A comprehensive literature assessment helped guarantee the study's content validity magnitude. Convergent validity is indicated by the fact that every factor in the confirmatory factor analysis has a loading larger than 0.50 (Chau, 1997). The environmental dimension in SP has a lower loading factor than other dimensions. This is caused by two main factors. Firstly, there is a need for more awareness or understanding and differences in perception among respondents regarding the impact of environmentally friendly practices compared to economic and social considerations. Secondly, the absence of derived standard operating procedures (SOPs) from maintenance activities that consider environmental regulations leads to

less emphasis on environmentally friendly practices. According to Hair et al. (2010), approval is granted to AVEs larger than 0.50 and composite reliability better than 0.70. Multicollinearity was evaluated using variance inflation factors (VIFs) and tolerance. There is a multicollinearity issue when the tolerance of “*f*” is less than 0.2 or the VIF value is higher than 4.0.

Table 3 diagonal elements show good construct validity, as indicated by their correlation coefficient being higher than the value of other variable coefficients below it. These findings show that the instruments can reliably measure construct variables well (Fornell and Larcker, 1981).

Table 3. Fornell-Larcker criterion of research (Source: data processed, 2023).

	RL	SP	MMI	AO
RL	0.772	-	-	-
SP	0.595	0.734	-	-
MMI	0.652	0.582	0.777	-
AO	0.763	0.590	0.704	0.780

Based on the comparison of the R^2 values for the total effect and mediation effect in **Figure 2a**, it can be seen that RL directly influences SP with an R^2 of 0.369. This means that there are other variables that influence SP and it can be seen in **Figure 2b**, the mediation of MMI and AO can increase the influence on SP with an R^2 of 0.433. **Table 4** below shows how well the latent variables are described by the measuring variables in the relationship model using mediation.

Based on **Table 4**, the model has moderate predictive ability, and variability in latent variables is well explained by its measuring variables, which is considered adequate for prediction purposes. The results of predictive relevance testing in **Table 4** can be interpreted as the Q^2 value being positive. Hence, the model has a positive predictive ability in samples that were not used during the estimation process. AO shows the highest R^2 value and with moderate category; this indicates that the model can provide a picture of 58.1% variability, but there is some variability that the research model does not explain. If measured from the R^2 and Q^2 values, the model has appropriate predictive power because the coefficient of determination for the three dependent constructs is in the moderate category and has a predictive relevance above 0.

Table 4. R^2 and Q^2 test results (Source: data processed, 2023).

Variable	R^2	Q^2
Y_Sustainable performance	0.433	0.224
Z1_Maintenance management implementation	0.425	0.250
Z2_Agile organization	0.581	0.348

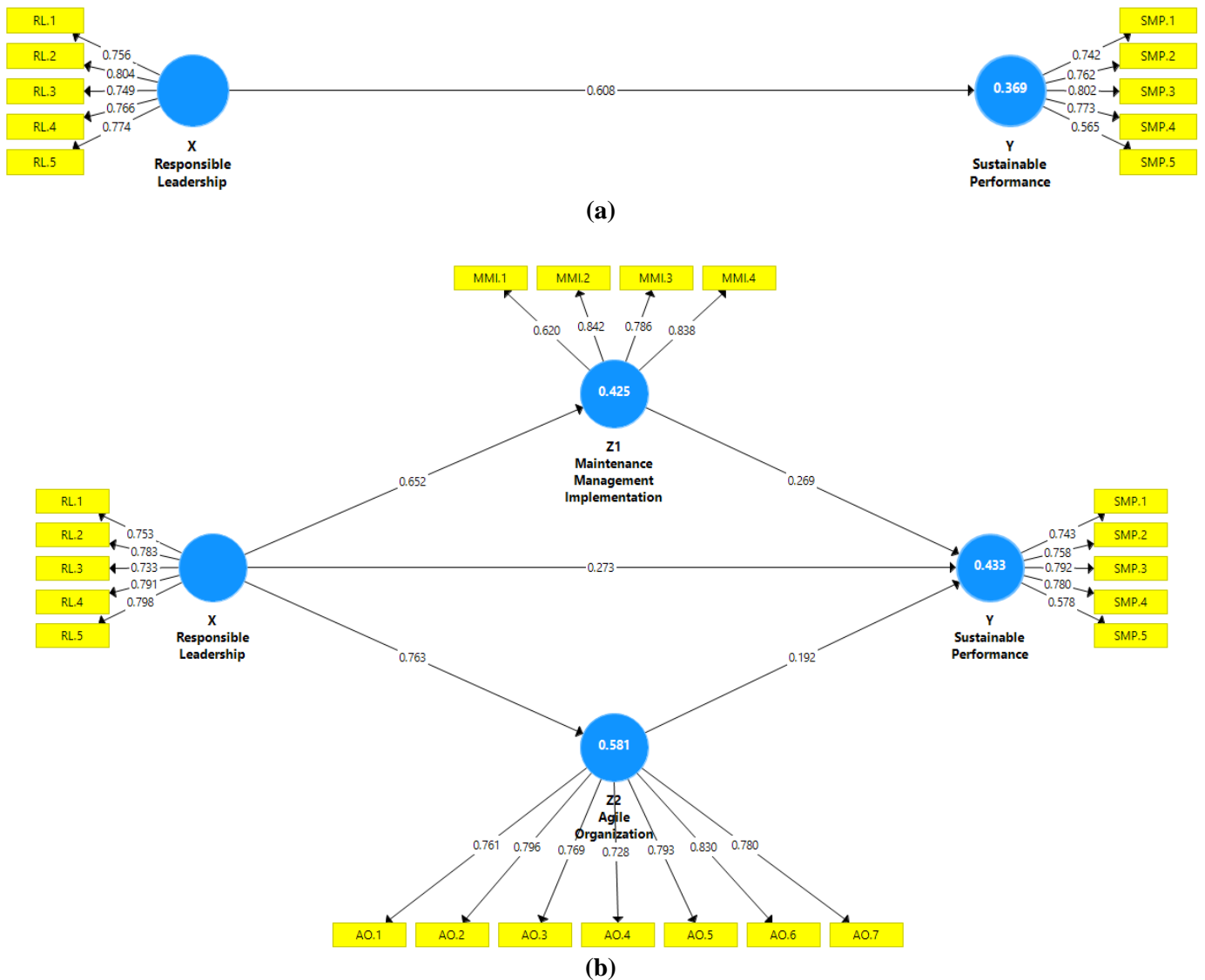


Figure 2. Path analysis of research and structural model. (a) a model with the total effect; (b) a model with mediation effect.

Hypothesis testing is used to test the absence of influence of the independent variable on the dependent variable in this research model. The results of hypothesis testing in this research can be seen in **Table 5** below.

Based on **Table 5**, it can be seen that all three hypotheses have H_a accepted and H_0 rejected. RL is positively influential and significant on SP, and it can be interpreted that an increase in one RL unit will increase SP by 27.3%. MMI mediates the relationship between RL and SP positively and significantly, with an increase of 17.5% for every one unit increase in RL through MMI. The hypothesis test on the AO mediator role showed a positive and significant mediation of the RL variable against SP, where it can be interpreted that an increase of one RL unit will increase SP by 14.7% through the AO role. Based on the direct influence and indirect influence (mediation) in the research model shown in Table 5 above, by multiplying the original sample, the path traversed produces a positive significance value, thus indicating a complementary partial mediation procedure (Hair et al., 2017).

Table 5. Hypothesis testing of the research (Source: data processed, 2023).

H	Hypothesized relationship	Original sample (O)	Standard deviation (STDEV)	T Statistics (O/STDEV)	P values	Information
H ₁	X_Responsible leadership → Y_Sustainable performance	0.273	0.098	2.796	0.005	Hypothesis accepted
H ₂	X_Responsible leadership → Z1_Maintenance management implementation → Y_Sustainable performance	0.175	0.040	4.435	0.000	Hypothesis accepted (complementary partial mediation)
H ₃	X_Responsible leadership → Z2_Agile organization → Y_Sustainable performance	0.147	0.062	2.373	0.018	Hypothesis accepted (complementary partial mediation)

5. Discussion

Although we found some support for the hypothesis that became the basic model as a reference in this study, the modification of the model by adding AO and MMI was carried out to develop a model suitable for application in the maintenance activities of Aloptama BMKG. Only now has the government institution engaged in meteorology, climatology, and geophysics to analyze the model with SP outputs at the national and global levels. The available literature used as a reference in this research model discusses RL, which influences SP directly and indirectly. The variables in the previous literature are slightly different. They are considered not to be by Aloptama BMKG’s independent maintenance practices that have been implemented, so adaptations or adjustments are made, such as management practice to implementation management in maintenance.

In this research model, the critical role of responsible leadership (RL) for sustainable performance (SP) with the output of measuring indicators using the triple bottom line (TBL) approach is the main focus that is considered to affect the maintenance of Aloptama BMKG. Responsible leadership in this model includes organizational culture, human resource practices, and managerial support that is organized and understood as basic concepts in applying BMKG. Several studies have deeply understood RL’s vivacious and significant influence on SP (Fathony et al., 2020; Javed et al., 2020; Rahim and Ullah Shah, 2020). According to Javed et al. (2020), responsible leadership considerably influences SP’s economic, social, and environmental performance dimensions. While earlier research by Nor-Aishah et al. (2020) and Phillips et al. (2019) has confirmed the beneficial effects of socially conscious leaders and entrepreneurial leadership on environmental and social performance, this has yet to be demonstrated for economic performance.

In line with the results and hypothesis, we discovered that RL directly and positively affects an organization’s ability to execute sustainably. Furthermore, the influence of RL on an organization’s long-term performance is gradually transmitted through epistemic motivation and the application of management support. Our research contributes to the understanding of responsible leadership by confirming that the actions of individual leaders who apply a tripartite view of responsible leadership can significantly influence sustainability. The tripartite view based on the responsible leadership aspect is as follows: (1) employee perceptions of a robust organizational culture that supports socially responsible and ethical actions, (2) fair and inclusive

human resource practices, and (3) managerial support positive for employee development and success. This report reveals these findings and offers a method for investigating the relationship between human behavior and its impact on the environment, which is the essence of responsible leadership. Our research confirms and emphasizes the findings of a study by Liao and Zhang (2020) that responsible leadership possesses attributes that facilitate cultivating sustainable practices among its employees. The results of this study provide strong support for the theory that RL contributes positively to the economic, social, and environmental aspects of TBL in the context of SP in BMKG. The importance of RL in creating and strengthening an organizational culture that supports sustainability is an essential foundation to achieve SP by embracing the principles of triple bottom line and applied to the maximum in the maintenance process of Aloptama BMKG.

In organizations implementing responsible leadership, the positive influence on sustainable performance can be understood through the mediating effect of implementing maintenance management. Responsible leaders view their responsibilities towards economic, social, and environmental aspects and ensure that sustainability principles are applied in every operational aspect, including the maintenance of Aloptama BMKG. Azadi et al. (2011) have examined that leaders or power holders, as policymakers, have complete control over organizational management. An organizational system that can run well or not is certainly influenced by the figure of the leader responsible for it.

Therefore, a responsible leader who can guide his team is needed to form a sustainable organizational performance system. For operational problems regarding equipment performance, BMKG needs a leader who can direct technician employees to achieve sustainable performance through good maintenance management. Liao and Zhang (2020) found that RL positively affects governance (practice) implementation. This aligns with the test results in this research model, which shows that implementing effective maintenance management is an essential bridge between RL and SP. RL creates an organizational culture that encourages the implementation of SP, and a good MMI serves as a critical mediator in responding to that leadership directive. This research shows that the application of MMI can be a channel through which the positive impact of RL is integrated into BMKG's Aloptama maintenance practices. Implementing maintenance management focusing on sustainability can lead to the TBL pillar, which should be considered when applying techniques, performance measurement, and policies in the maintenance process. Thus, in BMKG, with the findings of the application of RL, MMI can act as a crucial mediation element in building a positive relationship between sustainability principles in TBL, which indirectly impacts SP.

In the literature review, "AO" is crucial in driving organizational performance. However, there is something new in this research model: AO is placed as a mediator in RL practice with effectiveness in SP management. This concept reflects the ability of organizations to adapt to environmental changes and take innovative steps to respond to the challenges faced. Previous literature reviews discussed in this paper found that RL in some studies partially does affect AO. Based on the hypothesis test in **Table 5** above, confirming the previous theory and its application to the mediator model showed a significant influence. This shows that when implementing the

maintenance of Aoptama BMKG, adopting agile principles can accelerate the decision-making process, increase operational flexibility, and stimulate innovation. In this context, RL's sensitivity to the environment and social responsibility can be translated into AO practices that support SP. The ability of collaborative networks in agile organizations will help increase the influence of sustainability practices (Jadhav et al., 2019). Directly, agile practices have a positive and significant influence on sustainable performance, but as mediators' agile variables are found to be consistent with positive and significant values (Geyi et al., 2020).

Only a few studies discuss the role of AO mediation. However, as a basis for behavior in the agile component, this study shows that digital mindset, collaboration, adaptability, innovation, and speed of decision making can be adapted with good influence. The test results in which RL significantly affects SP through AO's mediation role show that the organization's ability to adapt to change, respond quickly to maintenance needs, and respond to sustainable performance demands is the result and culture initiated by responsible leaders. This proves that implementing sustainability principles in maintenance is the leader's responsibility and the result of an organizational culture that is responsive and adaptive to change.

6. Conclusion

Based on the literature study and analysis, this research focuses broadly on variables that can encourage interest. The results of this study provide advanced knowledge about sustainable performance and confirm phenomena that have yet to be well described before in the maintenance of Aoptama or others. The explanation of the phenomenon based on this explanatory research found that the role of RL can clearly drive and improve SP both directly and with the mediation of MMI and AO. In our research, leaders across BMKG units throughout Indonesia understand that elements related to managerial support should be addressed. This is by the wishes of technician employees who appear through the results of questionnaires as the majority of respondents in the study. To improve the managerial support element in the organization, RL needs to provide emotional support during high job pressure during maintenance and opportunities and support for employees to improve skills and competencies. Increasing employee capacity can be done through training, workshops, and mentorship programs to support the conduct of advanced lectures that help employees grow professionally.

According to our research, a positive relationship exists between RL and organizational strategies to increase environmental awareness based on the value of environmental factors. However, it has the lowest validity value even in the valid category. RL must understand that sustainability is an ethical responsibility and fundamental to maintaining ecosystem balance and supporting long-term well-being. As a result, RL needs to encourage implementing policies and practices that prioritize nature conservation directly and through AOs by creating responsive and mindset systems that take advantage of technological developments and through MMI by creating policies that include environmentally friendly maintenance guidelines. By increasing the role of RL in Aoptama maintenance, we finally propose a renewable conceptual framework that has a positive impact on SP through the mediation of AO

and MMI so that it can add to the literature that has been empirically tested.

Each country has a different culture, conditions, and situation, and the current research population is only limited to BMKG, which consists of employees directly and indirectly involved in the maintenance of Aloptama. There are some limitations to consider in future research. In this study, we only discuss the impact of RL, which is analyzed from the point of view of the use of organizational culture, human resource practices, and managerial support components. Future research can try other RL building blocks to increase knowledge about their impact on SP. Further research can especially investigate the aspects that encourage the development of the SP to adjust the phenomena that are hot and tested quantitatively, qualitatively, or with mixed methods. In addition, further research can use the model in this study to analyze the most significant influence of SP in other organizations or companies. Finally, we encourage future researchers to investigate the impact of alternative leadership styles or other alternative mediating factors that can support sustainable performance.

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