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Climate Change Mitigation Action in Optimizing Adiwiyata School Infrastructure Assets, Malang City, Indonesia

Arif Dermawan[1]*, Bambang Budi Wiyono[2], Ali Imron[2], Imron Arifin[2], Ursula Busert[3] and Shom Teoh[4]

[1]Doctoral Program, Education Management Department, Universitas Negeri Malang, Indonesia
[2]Education Management Department, Faculty of Education, Universitas Negeri Malang, Indonesia
[3]Policy Advice for Environment and Climate Change, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Team Leader
[4] Programme Manager, Sustainable Cities

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ABSTRACT

Climate change is a global issue that all parties must address. To address the challenge of mitigating the disaster's impact, the Adiwiyata School in Malang City is mitigating climate change through the use of the Measurement - Reporting - Verification (MRV) method for air quality measurement. This activity involves recording PM2.5 monitoring data, temperature, and humidity on a daily basis with the goal of obtaining and analyzing air quality data that affects all school-related activities. Climate change mitigation actions utilizing MRV are expected to optimize the management of school infrastructure assets in accordance with their condition. The research collected monitoring data for PM2.5, temperature, and humidity and organized them according to categories that serve as guidelines for the use of measuring instruments (PM2.5 detectors) in conjunction with the Regulation of the Indonesian Minister of Environment and Forestry concerning the Air Pollutant Standard Index converted to a Scatter Diagram. Air quality data collected via the MRV process is used to inform the infrastructure asset management process, particularly during the asset use phase. It is concluded that climate change mitigation efforts undertaken by schools in the area of air quality can provide a holistic picture and contribute significantly to optimizing the management of Adiwiyata School infrastructure assets.

Key words : *Climate change mitigation, PM2.5, Assets and infrastructure management, MRV*

Introduction

Climate change's catastrophic impact on livelihoods, tangible and intangible assets continues to be scrutinized on a global scale. Depending on the hazard and exposure level, broad disaster risks associated with urbanization, environmental degradation, asset-economic disparities, and poor management of urban assets indicate a greater accumulation of losses than death, economic, and physical damage (Shaw, 2010). Climate change has a significant impact on the current condition of our assets, and SDG 13 (Climate Action) makes asset management mitigation a priority in order to address climate change and its consequences (Campbell *et al.*, 2018).

Infrastructure asset management is a synthesis of management, finance, economics, and other disciplines applied to physical assets with the goal of

delivering the required level of service at the lowest possible cost for both current and future needs. It encompasses the entirety of an asset's life cycle, including its design, construction, commissioning, operation, maintenance, repair, modification, replacement, or deletion (Giglio *et al*., 2018). Increased capacity and optimal operation of infrastructure can contribute significantly to achieving the Sustainable Development Goals (SDGs) and making cities and human settlements more inclusive, safe, and sustainable (Arimah, 2017).

Malang City currently has over 125 high school units, and according to CSIRO (Commonwealth Scientific and Industrial Research Organization), infrastructure development is the most vulnerable to climate change impacts. As such, schools, as a form of public infrastructure, are an integral part of the city's climate change mitigation strategy (Puspita *et al.,* 2010).

Methods for inventory management should be practical and operational. GHG and anthropogenic removals on managed land are defined as anything on managed land in agriculture, forestry, and other land use sectors. Managed land is land that has been manipulated by humans to enhance production, ecological, and social functions. GHG emissions from unmanaged land do not need to be reported. However, it would be prudent for the state to quantify and track the area of unmanaged land over time in order to ensure consistent reporting as land use changes (Agus Sutopo, 2014). One of the negative consequences of exposure to airborne particulates, particularly those with a diameter of less than 2.5 microns (PM2.5) is an increased risk of respiratory disease (Achmadi, 2012).

The results of the study (Idris *et al.,* 2016) show that the management of school facilities and infrastructure includes the processes of planning, use, supervision, and elimination. Management of high school infrastructure assets in Malang City focuses on the aspect of monitoring air quality in dealing with the impacts of climate change, seeking to determine effective strategies through Measurement Reporting and Verification (MRV) (IGES, 2015)), the process of mitigating the impacts of climate change on assets. Adiwiyata School infrastructure in Malang City. These measures are expected to address climate change by integrating it into policies, strategies and planning in addition to improving education, increasing human and institutional awareness and capacity in mitigation, adaptation, impact reduction and early warning of climate change (Temuulen Murun, 2020).

The study's findings (Idris *et al*., 2016) indicate that school facility and infrastructure management encompasses the processes of planning, use, supervision, and elimination. The management of secondary school infrastructure assets in Malang City is focused on the aspect of air quality monitoring in order to mitigate the effects of climate change, with the goal of determining effective strategies through Measurement Reporting and Verification (MRV) (IGES, 2015), a process for mitigating the effects of climate change on school infrastructure assets. Malang Adiwiyata These measures are expected to address climate change by mainstreaming it into policies, strategies, and planning, as well as increasing education, human and institutional awareness, and capacity for climate change mitigation, adaptation, impact reduction, and early warning (Temuulen Murun, 2020).

Methods

The data used in this study are PM2.5 monitoring data, temperature and humidity observations taken daily by students or teachers at the research subjects' schools, SMPN1, SMP Plus Al Kautsar, and SMPK Sang Timur.

Air quality measurements were taken in three secondary schools as part of global thinking and applied through local wisdom that reflects the school's environmental and cultural vision (KLH, 2013). As a foundation for MRV implementation, (IGES, 2015) it is recognized that six challenges must be addressed, namely:

- Data: data kurang atau tidak cukup
- Kapasitas teknis: kapasitas teknis terbatas
- Sistem kelembagaan: sistem kelembagaan yang sesuai tidak tersedia
- Pendanaan: dana kurang atau tidak cukup
- Sumber daya manusia: sumber daya manusia tidak ada atau tidak memadai
- Kesadaran: kurangnya kesadaran tentang MRV dan pentingnya MRV
- Data: insufficient or insufficient data
- Technical capacity: limited technical capacity
- Institutional system: suitable institutional system is not available
- Funding: insufficient or insufficient funds
- Human resources: non-existent or inadequate human resources
- Awareness: lack of awareness about MRV and

the importance of MRV

Effective climate change mitigation requires a firm grasp of greenhouse gas (GHG) emissions and their sources, as well as ongoing monitoring of mitigation strategies and their effects. The practice of "MRV" is critical in this regard, as it integrates three distinct processes but is related to measurement or monitoring (M), reporting (R), and verification (V) (Romijn *et al.,* 2018). The following steps and procedures are involved in MRV (Bertoldi *et al.,* 2018):

Emission data and information, mitigation actions, and support are measured or monitored (M). This may require direct physical measurement of GHG emissions, estimation of emissions or the use of data and emission factors from emission reduction activities, calculating changes necessary for sustainable development, and gathering information on support for climate change mitigation.

Report (R) by compiling this information into inventories and other standard formats to make it accessible to a variety of users and to facilitate public disclosure.

Verification (V) is accomplished by subjecting reported data to some form of review, analysis, or independent assessment on a periodic basis to determine its completeness and reliability. Verification enables the assurance of accuracy and compliance with established procedures, as well as the provision of actionable feedback for future enhancements.

The following step is to validate the data on school infrastructure assets (Moses Demetouw, 2017). Infrastructure asset management is the process of managing facilities and infrastructure, including planning, use, monitoring, and elimination, with the goal of optimizing the utilization of these asset services (Ria Asih Aryani Soemitro1, 2018), as well as risk and cost management associated with air quality on school infrastructure assets over the asset's life.

Results and Discussion

The combination of low-cost particulate matter MRV implementation and online data collection through the website https://aremaclimatecare.org/apl/?menu=home enables us to address the six challenges inherent in MRV implementation (IGES, 2015)

Daily average PM2.5 concentration values from February 12 to July 16, 2020, as monitored at three schools, SMPN1, SMP Plus Al Kautsar, and SMPK Sang Timur. Then, using the ISPU manual book tool (PM2.5 detector) range category, the Air Pollution Standard Index (ISPU) (KLHK, 2020) is verified. The majority of low-cost particulate matter sensors (LCPMS) used today are capable of accurately monitoring PM changes in the environment and demonstrating reasonable performance with reasonable accuracy (Alfano *et al*., 2020).

Qualitative results were obtained in the form of a PM2.5 monitoring scatter diagram (Umara Firman Rizi and Mizani Ahmad, 2019) as follows.

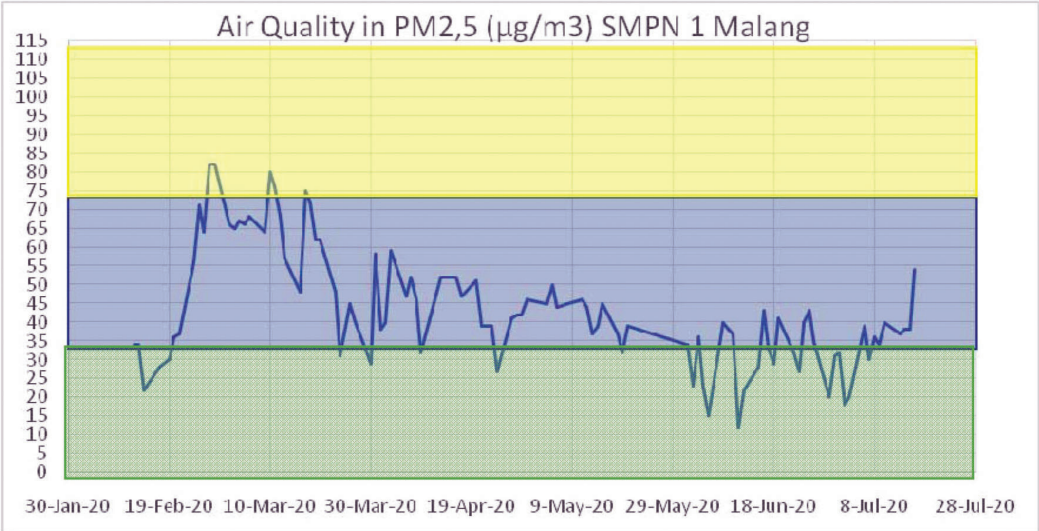
Category Numbers Range API **

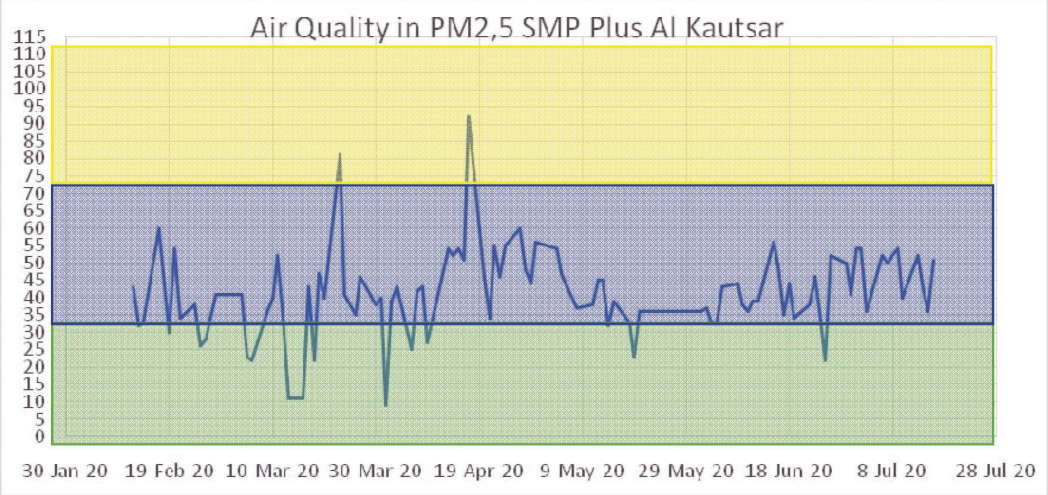
Air Quality Category		Color Status	Range Number (mg/m3)
5	Great	Green	0 – 35
4	Good	Blue	35 – 75
3	Mildly Polluted	Yellow	75 – 115
2	Moderately Polluted	Red	115 - 150
1	Seriously Polluted	Black	150 - 250
0	Severely Polluted	Black	S 250

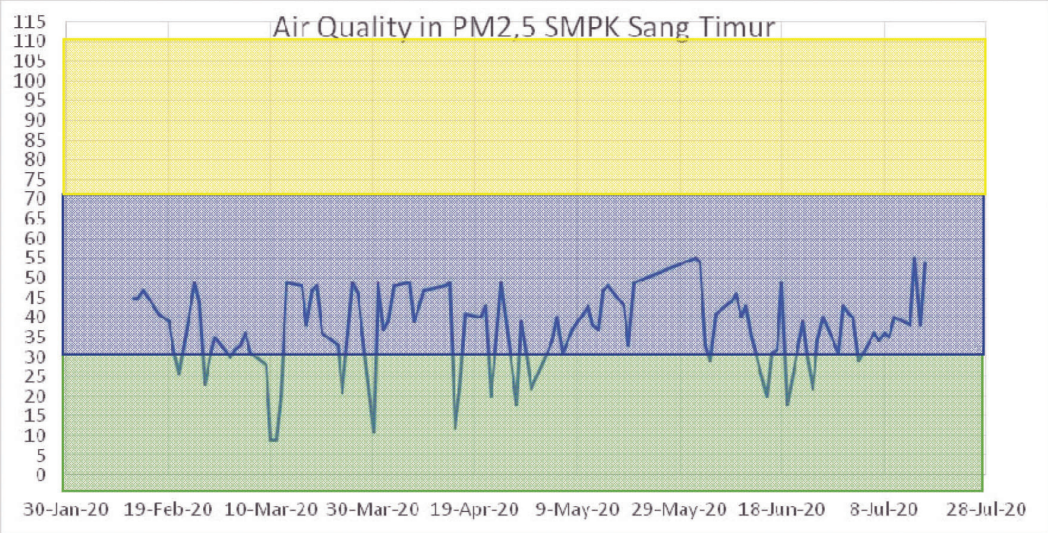
** Air Poluttan Index $PM^{2,5}$ Detector user guidance (SNDWay)

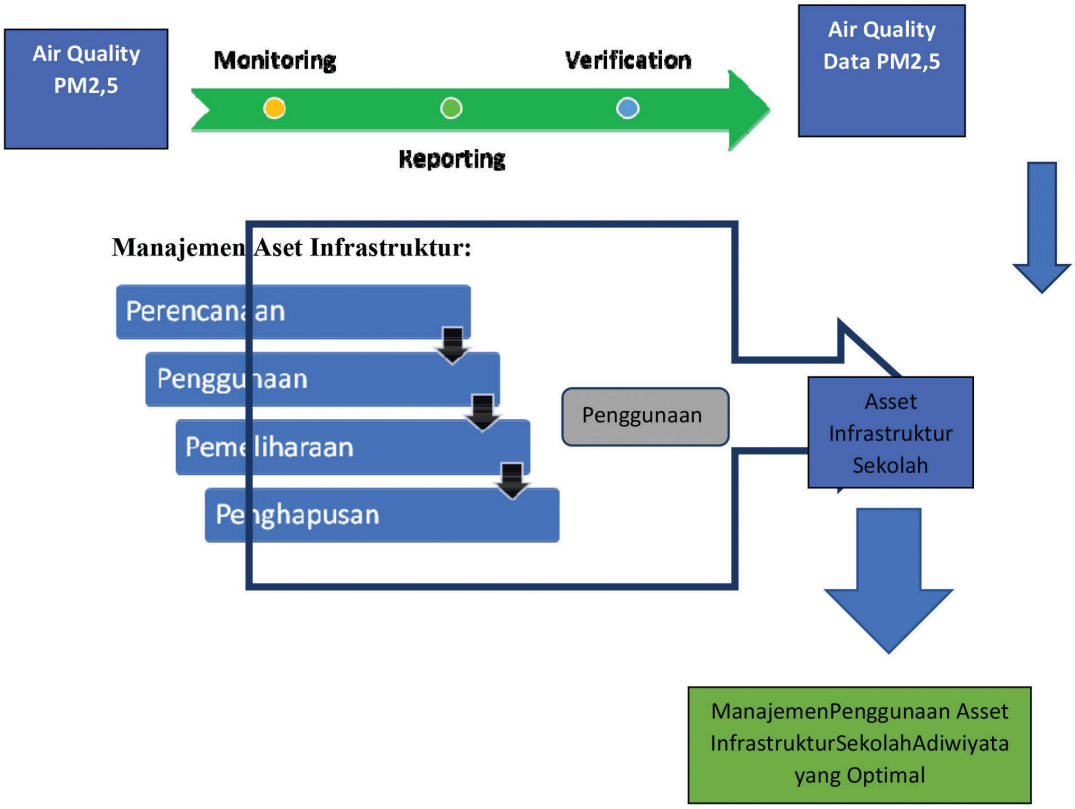
Table 1. School Assets and Infrasturcture

	SMP Negeri 1	SMP Plus Al Kautsar	SMPK Sang Timur
Field area (m^2)	6.200,00	1.509,00	4.354,50
Building area (m^2)	3.426,00	1.200,00	538,00
School yard (m^2)	800,00	488,00	1.335,00
Sport yard (m^2)	1.380,00	180,00	300,00


Air Quality in PM2,5 (µg/m3) SMPN 1 Malang
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
30-Jan-20
19-Feb-20
10-Mar-20
30-Mar-20
19-Apr-20
9-May-20
29-May-20
18-Jun-20
8-Jul-20
28-Jul-20


Air Quality in PM2,5 SMP Plus Al Kautsar
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
30 Jan 20
19 Feb 20
10 Mar 20
30 Mar 20
19 Apr 20
9 May 20
29 May 20
18 Jun 20
8 Jul 20
28 Jul 20


Air Quality in PM2,5 SMPK Sang Timur
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
30-Jan-20
19-Feb-20
10-Mar-20
30-Mar-20
19-Apr-20
9-May-20
29-May-20
18-Jun-20
8-Jul-20
28-Jul-20



According to the results of a hundred days of monitoring scattered air quality diagrams, SMPN 1 Malang was found to be in good condition on 29 days (green), moderate condition on 67 days (blue), and lightly polluted on 4 days (yellow).

SMP Plus Al Kautsar was monitored for 26 days in good condition (green), 72 days in moderate condition (blue), and two days in lightly polluted conditions (yellow) .

SMPK Sang Timur was observed in good condition (green) for 39 days and in moderate condition for 61 days (blue).

The management of school infrastructure assets entails the planning, use, monitoring, and disposal of these assets. This activity focuses on the use of school assets and is accomplished through an assessment of air quality and its relationship to the optimization of infrastructure assets as part of climate change mitigation efforts (Kumar *et al.,* 2019).

Conclusion

It can be concluded that the air quality in the three majority schools (over 50% of total data) is moderate (blue); however, it should be noted that the majority of data collection occurred during the implementation of the Large-Scale Social Restrictions (PSBB); this information can be used to evaluate the next activity after the PSBB regulations are repealed. The MRV process should be enhanced by the use of sensors/detectors that have been recognized/calibrated in accordance with established measurement standards. This activity is sufficient to provide students and related teachers or instructors with a foundation of knowledge and awareness regarding climate change mitigation efforts, particularly in terms of optimizing the facilities / assets of school infrastructure used.

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