The study of greenhouse gas emissions in village level to support the “PROKLIM” program: case Study of Poncosari Village, Yogyakarta - Indonesia

Andung Bayu Sekaranom¹,², Ambar Kusumandari³, Suratman¹
¹ Department of Environmental Geography, Faculty of Geography, Universitas Gadjah Mada – Yogyakarta 55281 Indonesia
² Research Center for Disaster Universitas Gadjah Mada – Jl. Mahoni No. C16 Bulaksumur Yogyakarta 55281 Indonesia
³ Faculty of Forestry, Universitas Gadjah Mada Jl. Agro No. 1, Bulaksumur, Sleman 55281, Yogyakarta, Indonesia
andung.geo@ugm.ac.id

Abstract. In Indonesia, PROKLIM is one of the major adaptation and mitigation actions that conducted at the local (community) level. The activities that need to be accelerated and capacity building and mainstreamed in various development activities and existing community activities to support the green house gases (GHG) reduction at national level. The general purpose of this activity is to strengthen the program in increasing understanding about climate change and its various impacts and encourage implementation of real actions in the community. To support this goal, an inventory of greenhouse gas emissions was carried out at the village level, one of which was Poncosari Village located in Bantul Regency, Special Region of Yogyakarta, Indonesia. The GHG emissions inventory is carried out for the domestic, transportation, and livestock sectors. The inventory is carried out by surveying each hamlet in the village. The results of the analysis show high emissions from the livestock sector. The contribution of the domestic sector occupies the second position due to the use of firewood.

1. Introduction
The Paris Agreement is one of the most important multilateral environmental agreements adopted by more than 190 parties at Conference of the Parties (COP) 21 in 2015 [1]. Indonesia has a commitment to participate in controlling global climate change as mentioned in the Paris Agreement. The commitment to controlling climate change is a manifestation of the Constitutional mandate of the Republic of Indonesia as contained in the 1945 Constitution and Article 28 H letter (1). The constitution mandate states that Indonesia supports climate change control as obliged to protect its country [2]. The geographical and geopolitical position of Indonesia as the largest archipelagic country in the world has a large influence in controlling the future climate [3] as well as affected by the climate [4–7].

The Indonesia archipelago contains extensive tropical rain forests, peatlands, coastal, and marine ecosystems that play important role in reducing the impact of global climate change [8–10]. One of the the Paris Agreement objective is to prevent a rise in the earth's average surface temperature below 2°C compared to the pre-industrial era. As an implementation of this commitment, Indonesia has a target for Nationally Determined Contributions (NDC) to reduce GHG emissions by 29% by 2030 on its own to 41% if there is international cooperation [11]. The NDC are targeted GHG emission reductions in forestry (17.2%), energy (11%), agriculture (0.32%), industry (0.10%) and waste (0.38%).

Based on the Minister of Environment and Forestry Regulation Number P.84/MENLHK-SETJEN/KUM.1/11/2016, the Ministry of Environment and Forestry of Indonesia (KLHK) designs and develops a community-based climate change control program, known as the Climate Village Program (PROKLIM). This program aims to encourage community and stakeholder involvement to strengthen capacity in adaptation actions to various impacts of climate change and GHG emission reduction mitigation actions as well as to give recognition to community self-reliance [12]. The PROKLIM is intended to have a dual purpose, namely controlling climate change along with improving social welfare.
and economy at the community-based site level in accordance with regional conditions. This supports low-carbon and climate-resilient development [13]. The PROKLIM, as an adaptation and mitigation action at the local level, needs to be accelerated and increased in capacity and mainstreamed into existing community activities and future development plan. Moreover, if it is associated with the National Medium-Term Development Plan (RPJMN) in 2020-2024, there are target areas of 20,000 PROKLIM villages. However, Based on the 2020 baseline, there are only 2,146 PROKLIM village where most of them are spread out on the Java Island. Meanwhile, the number of villages in Indonesia is 83,931 villages located in 34 provinces. So it is still far from adequate in terms of quantity and quality. The PROKLIM program aims that every individual and community is expected to become an agent of change from wasteful lifestyles and habits to become environmentally friendly by creating adaptive and low-carbon patterns of life. The PROKLIM is expected to be able to provide solutions related to climate that are carried out easily, cheaply, simply, quickly and immediately lead to tangible results. These various actions are supported by various climate literacy activities to improve the knowledge and skills of individuals and community groups in formal, non-formal, and informal education. One of the activities that need to be carried out before carrying out community-based activities is the preparation of a greenhouse gas emission (GHG) profile in the local level. The profiling aims to identify priority sectors that need to be addressed first to reduce the GHG. This paper aims to 1) analyze greenhouse gas emissions at the village level, which includes the domestic, transportation, and livestock sectors, and 2) identify climate change mitigation and adaptation effort by the local community. By identifying the largest GHG emitting sector and current mitigation and adaptation efforts, community-based activities can be integrated to target to reduce the GHG produced by the sector.

2. **Data and methods**

Poncosari Village is a village located in the Srandakan sub-district, Yogyakarta-Indonesia. The village consists of 24 hamlets (sub-village level). The area of the village is 1,186,1220 hectares with a topography lowlands and coastal areas. There are several beach tourism destinations in Poncosari Village, including Kuwaru Beach, Pantai Baru Beach, and Cangkring Beach. The main problem for the beaches in Poncosari Village is abrasion alongside the coastline. It is predicted that the level of abrasion will increase due to climate change [14]. The increase in the number of tourists on several beaches, especially Pantai Baru Beach, also has contributed to the waste problem. In addition, in terms of the poverty level, Srandakan District is one of the sub-districts in Bantul Regency with a moderate poverty level. Based on the above problems, the poncosari village is suitable for implementing activities related to PROKLIM. Thus, in formulating the right type of activity, it is necessary to identify sectors that contribute to GHG emissions as well as develop mitigation and adaptation strategies for climate change impacts. The activity of compiling the GHG emission profile in Poncosari Village is carried out in three sectors, including the domestic sector, the transportation sector, and the livestock sector. Emissions from the domestic sector are based on the number of households and the type of fuel used, mainly for cooking. Emissions from the transportation sector are based on the number and type of vehicles, as well as the average trips taken in one day. Emissions from the livestock sector are carried out by taking into account the type and number of livestock. The unit area of analysis in this preparation is for the hamlet unit (Figure 1). Data was obtained by conducting a survey of all of the above parameters as well as interviews with the head of the hamlet. Field activities were carried out to obtain the above information in May 2021. Furthermore, the data was processed using MS excel and mapped using QGIS software.
Figure 1. Hamlet Map of Poncosari Village, Yogyakarta-Indonesia (Source: field survey in 2021)

The GHG emission from domestic sector is calculated for CO\(_2\), CH\(_4\), and N\(_2\)O. The result is presented in term of CO\(_2\) equivalent. The emission from domestic sector is calculated using the annual energy consumption or usage multiplied by the emission factor conversion (Table 1). The emission factor is determined using type of domestic energy usage (e.g. LPG, Kerosene, Firewood, etc.). The GHG emission from transportation sector is focused on CO\(_2\). The emission is determined based on type of vehicle, namely motorcycle, car, truck, diesel based vehicle, and bus (Table 2). Based on the field interview, the average daily trip for each person is 5 km, while the total CO\(_2\) emission can be calculated from the number of vehicle multiplied by average daily trip multiplied by 365 days, and then multiplied by the CO\(_2\) emission factor. The GHG emission from livestock sector is focused on CH\(_4\) and N\(_2\)O. The GHG emission is calculated based on the number of livestock multiplied by livestock emission factors, which are different between cow, sheep, pig, and poultry (Table 3).

**Table 1.** Emission factor for domestic sector (Source: KLHK 2017)

| Domestic Energy Usage | CO\(_2\) | CH\(_4\) | N\(_2\)O |
|-----------------------|---------|---------|---------|
| LPG                   | 63,100  | 1       | 0.1     |
| Kerosene              | 71,900  | 3       | 0.6     |
| Brown Coal Bricet     | 97,500  | 10      | 1.5     |
| Peat Bricket          | 106,000 | 10      | 1.4     |
| Firewood              | 112,000 | 300     | 4       |
| Charcoal              | 112,000 | 200     | 1       |
| Biogas                | 54,600  | 5       | 0.1     |

**Table 2.** Emission factor and energy consumption for transportation sector (Source: KLHK 2017)

| Vehicle | Motorcycle | Car | Truck | Diesel | Bus |
|---------|------------|-----|-------|--------|-----|
| Emission Factor (gr/l) | 3.180 | 3.180 | 3.172 | 3.172 | 3.172 |
| Energy consumption (l/km) | 0.0266 | 0.1179 | 0.185 | 0.1179 | 0.1689 |
Table 3. Emission factor for livestock sector (Source: KLHK 2017)

| Emission factor (kg CO$_2$e/year) | Cow   | Sheep | Pig  | Poultry |
|-----------------------------------|-------|-------|------|---------|
| CH$_4$                            | 1,008 |       | 109.62 | 525     | 4.62   |
| N$_2$O                            | 36,361.3 | 135,820.2 | 87,694.9 | 5347.25 |

To identify climate change mitigation and adaptation efforts at the local level, interviews were conducted with each hamlet head. Interviews were conducted with unstructured questions. For example, community activities that include planting trees, especially sea pine, as well as processing livestock waste.

3. Result and discussion

3.1. GHG emission from the domestic, transportation, and livestock sectors

The survey of domestic emissions in the form of CO$_2$ was conducted by interviewing the use of energy for household needs, especially cooking. The survey was conducted with hamlet units to obtain information on energy use in the form of LPG and firewood (Table 4). The survey results show that most of the heads of households in Poncosari Sub-district have used LPG, while a small proportion are still using firewood. Although fewer people use firewood, in terms of CO$_2$ emissions, the contribution from the use of firewood is higher than that produced by the use of LPG.

Table 4. CO$_2$ emission from the domestic sector (source: data analysis)

| No | Hamlet        | LPG  | Firewood | Total | No | Hamlet        | LPG  | Firewood | Total |
|----|---------------|------|----------|-------|----|---------------|------|----------|-------|
| 1  | Bodowaluh    | 14.51| 0.00     | 14.51 | 13 | Karang        | 24.18| 397.32   | 421.50|
| 2  | Jopaten      | 40.02| 286.07   | 326.09| 14 | Bibis         | 37.34| 158.93   | 196.27|
| 3  | Cangkring    | 24.18| 0.00     | 24.18 | 15 | Kralan        | 49.96| 0.00     | 49.96 |
| 4  | Babakan      | 67.15| 158.93   | 226.08| 16 | Koripan       | 47.81| 31.79    | 79.60 |
| 5  | Sambeng 3    | 48.35| 158.93   | 207.28| 17 | Kuwaru        | 54.80| 158.93   | 213.73|
| 6  | Ngentak      | 85.96| 0.00     | 85.96 | 18 | Bayuran       | 29.35| 238.39   | 267.74|
| 7  | Sambeng 2    | 46.74| 143.04   | 189.77| 19 | Godekan       | 38.82| 0.00     | 38.82 |
| 8  | Kukap        | 43.52| 0.00     | 43.52 | 20 | Gunturgeni    | 15.91| 79.46    | 95.38 |
| 9  | Jragan 1     | 53.45| 0.00     | 53.45 | 21 | Polosiyi      | 54.68| 158.93   | 213.61|
| 10 | Jragan 2     | 38.41| 0.00     | 38.41 | 22 | Singgelo      | 84.60| 158.93   | 243.53|
| 11 | Besole       | 37.61| 317.86   | 355.46| 23 | Talkondo      | 52.57| 0.00     | 52.57 |
| 12 | Sambeng 1    | 44.86| 238.39   | 283.25| 24 | Wonoingal     | 27.66| 158.93   | 186.59|

Total 3,907.25

The domestic emission survey in the form of CH$_4$ was conducted similar to CO$_2$ emissions from the use of LPG and firewood (Table 5). The survey results show that the CH$_4$ emissions of Poncosari Village are one hundred and sixty tons of CO$_2$ equivalent per year. This is lower than CO$_2$ emissions of almost four thousand tons per year. The highest CO$_2$ and CH$_4$ emissions are in Dusun Karang where the population is the highest. Data on the use of LPG and firewood are also used to estimate N$_2$O emissions in Poncosari Village (Table 6). The total emission of N$_2$O produced is thirty tons of CO$_2$ equivalent per year. Thus, the resulting emissions are also smaller than CO$_2$ emissions.
Table 5. CH4 emission from the domestic sector in CO2 equivalent (source: data analysis)

| No | Hamlet       | CH4 emission | No | Hamlet      | CH4 emission |
|----|-------------|--------------|----|-------------|--------------|
|    |             | LPG | Firewood | Total |             | LPG | Firewood | Total |
| 1  | Bodowaluh   | 0.00| 0.00     | 0.00  | 13 | Karang      | 0.01| 22.35    | 22.36 |
| 2  | Jopaten     | 0.01| 16.09    | 16.10 | 14 | Bibis       | 0.01| 8.94     | 8.95  |
| 3  | Cangkring   | 0.01| 0.00     | 0.01  | 15 | Kranan      | 0.02| 0.00     | 0.02  |
| 4  | Babakan     | 0.02| 8.94     | 8.96  | 16 | Koripan     | 0.02| 1.79     | 1.80  |
| 5  | Sambeng 3   | 0.02| 8.94     | 8.96  | 17 | Kuwaru      | 0.02| 8.94     | 8.96  |
| 6  | Sambeng 2   | 0.03| 0.00     | 0.03  | 18 | Bayuran     | 0.01| 13.41    | 13.42 |
| 7  | Bibis       | 0.01| 0.00     | 0.01  | 20 | Gunturgeni  | 0.01| 4.47     | 4.48  |
| 8  | Sambeng 1   | 0.01| 17.88    | 17.89 | 21 | Talkondo    | 0.02| 0.00     | 0.02  |
| 9  | Babakan     | 0.02| 2.49     | 2.52  | 24 | Wonotingal  | 0.01| 8.94     | 8.95  |

Total 160.37

Table 6. N2O emission from the domestic sector in CO2 equivalent (source: data analysis)

| No | Hamlet       | N2O emission | No | Hamlet      | N2O emission |
|----|-------------|--------------|----|-------------|--------------|
|    |             | LPG | Firewood | Total |             | LPG | Firewood | Total |
| 1  | Bodowaluh   | 0.01| 0.00     | 0.01  | 13 | Karang      | 0.01| 4.16     | 4.17  |
| 2  | Jopaten     | 0.02| 2.99     | 3.01  | 14 | Bibis       | 0.02| 1.66     | 1.68  |
| 3  | Cangkring   | 0.01| 0.00     | 0.01  | 15 | Kranan      | 0.02| 0.00     | 0.02  |
| 4  | Babakan     | 0.03| 1.66     | 1.69  | 16 | Koripan     | 0.02| 0.33     | 0.35  |
| 5  | Sambeng 3   | 0.02| 1.66     | 1.69  | 17 | Kuwaru      | 0.03| 1.66     | 1.69  |
| 6  | Sambeng 2   | 0.02| 1.50     | 1.52  | 19 | Godekan     | 0.02| 0.00     | 0.02  |
| 7  | Bibis       | 0.02| 0.00     | 0.02  | 20 | Gunturgeni  | 0.01| 0.83     | 0.84  |
| 8  | Babakan     | 0.02| 0.00     | 0.02  | 21 | Polosiyio   | 0.03| 1.66     | 1.69  |
| 9  | Sambeng 1   | 0.02| 1.50     | 1.52  | 22 | Singgelo    | 0.04| 1.66     | 1.70  |
| 10 | Jopaten     | 0.02| 1.50     | 1.52  | 23 | Talkondo    | 0.02| 0.00     | 0.02  |
| 11 | Sambeng 1   | 0.02| 2.49     | 2.52  | 24 | Wonotingal  | 0.01| 1.66     | 1.68  |

Total 30.26

The vehicle emission survey according to the GHG inventory guidelines issued by the Ministry of Environment and Forestry (KLHK) consists of CO2, NH4, and N2O. Identification of vehicle emission sources is carried out for each type of vehicle including motorcycles, cars, trucks, and buses. Assuming the daily trip is 5 km/day, then the estimated CO2 emission is more than 1000 tons/year for CO2 (Table 7). Meanwhile, CH4 and N2O emissions are very small and not considered in this paper.

The livestock emission survey includes GHG emissions consisting of NH4 and N2O (Table 8). Identification of emission sources in the livestock sector is based on the type of livestock, including cattle, goats, pigs and poultry. The results of the CH4 emission survey show that the emissions produced are almost the same as vehicle emissions, which is more than 1000 CO2 equivalent per year. Meanwhile, N2O emissions are the highest, at more than three hundred thousand tons of CO2 equivalent per year.
### Table 7. CO₂ emission from the transportation sector (source: data analysis)

| No  | Hamlet  | CO₂ emission | Motorcycle | Car | Truck | Diesel | Total |
|-----|---------|--------------|------------|-----|-------|--------|-------|
| 1   | Bodowaluh | 16.98        | 4.11       | 0.00   | 0.00   | 21.09   |
| 2   | Jopaten   | 19.30        | 8.21       | 0.00   | 0.00   | 27.51   |
| 3   | Cangkring | 27.79        | 2.05       | 0.00   | 0.00   | 29.84   |
| 4   | Babakan   | 40.14        | 20.53      | 0.00   | 0.00   | 60.66   |
| 5   | Sambeng 3 | 29.33        | 10.26      | 4.28   | 2.93   | 46.81   |
| 6   | Ngentak   | 49.40        | 22.58      | 0.00   | 0.00   | 71.98   |
| 7   | Sambeng 2 | 35.81        | 10.95      | 0.00   | 0.00   | 46.76   |
| 8   | Kukap     | 23.16        | 14.37      | 1.07   | 0.00   | 38.60   |
| 9   | Jragan 1  | 61.44        | 35.58      | 2.14   | 0.00   | 99.16   |
| 10  | Jragan 2  | 22.08        | 13.00      | 1.07   | 0.00   | 36.15   |
| 11  | Besole    | 49.40        | 17.79      | 0.00   | 0.00   | 67.19   |
| 12  | Sambeng 1 | 35.51        | 10.95      | 0.00   | 0.00   | 46.45   |
| 13  | Karang    | 35.51        | 7.53       | 0.00   | 0.00   | 43.03   |
| 14  | Bibis     | 23.16        | 13.68      | 0.00   | 0.00   | 36.84   |
| 15  | Krajan    | 57.43        | 17.11      | 3.21   | 0.00   | 77.75   |
| 16  | Koripan   | 55.57        | 13.68      | 1.07   | 0.00   | 70.33   |
| 17  | Kuwaru    | 33.04        | 10.26      | 1.07   | 0.00   | 44.37   |
| 18  | Bayuran   | 24.24        | 7.53       | 0.00   | 0.00   | 31.76   |
| 19  | Godekan   | 28.25        | 8.90       | 0.00   | 0.00   | 37.15   |
| 20  | Gunturgeni| 12.50        | 4.11       | 0.00   | 0.00   | 16.61   |
| 21  | Polosiyo  | 41.68        | 13.00      | 0.00   | 0.00   | 54.68   |
| 22  | Singgelo  | 63.45        | 19.84      | 0.00   | 0.00   | 83.29   |
| 23  | Talkondo  | 38.28        | 12.32      | 0.00   | 0.00   | 50.60   |
| 24  | Wonotingal| 22.08       | 6.84       | 0.00   | 0.00   | 28.92   |
|     | **Total** |             |            |       |       | **1,167.52** |

### Table 8. CH₄ emission from the livestock sector in CO₂ equivalent (source: data analysis)

| No  | Hamlet  | CH₄ emission | Cow | Sheep | Pig | Poultry | Total |
|-----|---------|--------------|-----|-------|-----|---------|-------|
| 1   | Bodowaluh | 24.19        | 5.92 | 0.00   | 0.76 | 30.87   |
| 2   | Jopaten   | 141.12       | 8.99 | 0.00   | 5.17 | 155.28  |
| 3   | Cangkring | 6.05         | 31.13| 0.00   | 4.62 | 41.80   |
| 4   | Babakan   | 201.60       | 8.77 | 0.00   | 6.01 | 216.38  |
| 5   | Sambeng 3 | 20.16        | 3.29 | 0.00   | 3.51 | 26.96   |
| 6   | Ngentak   | 90.72        | 3.07 | 0.00   | 2.96 | 96.75   |
| 7   | Sambeng 2 | 104.83       | 16.55| 0.00   | 1.90 | 123.28  |
| 8   | Kukap     | 49.39        | 6.14 | 0.00   | 2.02 | 57.55   |
| 9   | Jragan 1  | 30.24        | 16.44| 0.00   | 1.99 | 48.67   |
| 10  | Jragan 2  | 20.16        | 5.48 | 0.00   | 1.82 | 27.47   |
| 11  | Besole    | 48.38        | 4.60 | 0.00   | 7.39 | 60.38   |
| 12  | Sambeng 1 | 50.40        | 5.48 | 0.00   | 3.86 | 59.74   |
| 13  | Karang    | 60.48        | 3.29 | 0.00   | 1.59 | 65.36   |
| 14  | Bibis     | 75.60        | 0.00 | 0.00   | 1.38 | 76.98   |
| 15  | Krajan    | 137.09       | 2.74 | 0.00   | 1.72 | 141.55  |
| 16  | Koripan   | 40.32        | 16.44| 0.00   | 2.47 | 59.23   |
| 17  | Kuwaru    | 60.48        | 5.48 | 0.00   | 0.05 | 66.01   |
| 18  | Bayuran   | 48.38        | 6.03 | 0.00   | 2.07 | 56.48   |
3.2. Local community mitigation and adaptation

Programs related to the implementation of PROKLIM based activities that have been carried out in the community are identified by conducting surveys and field interviews with relevant stakeholders. In the coastal areas, the main effort is conducted by planting sea pine. This was done in the hamlets of Kuwaru, Ngentak, and Cangkring. In the Dusun Ngentak area, there is Pantai Baru Beach, which is currently well organized and visited by many tourists. In Kuwaru Hamlet, there is Kuwaru Beach which has affected by coastal abrasion. Last, cangkring Beach is currently planned for future tourism development. This is manifested in the coastal tourism master plans in the three hamlets.

The characteristics of the Poncosari Village, particularly the coastal area are basically very potential for the development of coastal tourism. However, village involvement in tourism activities has not been optimal. At this time, the village-owned enterprises (BUMDes) still have not seized opportunities in the tourism sector. On the other hand, the presence of sea pine trees in coastal areas, in addition to being in line with PROKLIM objectives, is also able to attract tourists at domestic scale. This is because the beach area in Poncosari Village, which includes Pantai Baru Beach, Kuwaru Beach, and Cangkring Beach has shady characteristics and is different from other beaches on the south coast of Yogyakarta.

In hamlets that are not bordered by the sea, the most common implementation are by planting crops and processing livestock manure as raw material for organic fertilizers. Waste processing is currently handled by the BUMDes of Poncosari Village, especially in processing organic waste into fertilizer. However, in terms of tourism, there is no specific design, especially in relation to things that are in line with GHG reduction.

Programs related to the implementation of Proklim activities that have been carried out in targeted communities are to strengthen BUMDes in supporting tourism activities in coastal areas that are in line with PROKLIM program. Basically, activities that are backboned by PROKLIM in coastal areas have been carried out by planting sea pine trees. The location that is the subject of development at this time is the Cangkring Beach area. Thus, it is necessary to participate in BUMDes in developing tourism activities at Cangkring Beach based on the concept of PROKLIM. Currently, BUMDes is still focusing on waste management, especially related to the manufacture of organic fertilizers. Meanwhile for tourism sector there are no related activities. By strengthening BUMDes towards tourism, it is hoped that new creative economic activities will grow that can increase public awareness in GHG reduction.

4. Conclusion

Characteristics of GHG emission profiles in rural areas can be different when compared to urban areas. In urban areas, high emissions often come from the industrial and transportation sectors. Meanwhile in rural areas, the characteristics of the area are still natural resulting in almost non-existent GHG emissions from industry. Meanwhile, community economic activities that focus on agriculture also result in commuting in shorter distances than urban areas. It has an effect on GHG emissions in the transportation sector which is lower than in urban areas. Meanwhile, GHG emissions from the domestic sector could be higher, especially if they still use raw materials that have a high emission factor, especially firewood. GHG emissions in rural areas can also be characterized by higher livestock sector emissions than urban areas. In rural areas, GHG emissions from the livestock sector can be higher than those from the transport sector. Thus, the most suitable strategy for reducing GHG emissions in rural areas is to utilize livestock manure as a producer of biogas energy and organic fertilizer.
This research still has weaknesses because several sectors have not been quantified, including those related to electricity consumption and tourism. Judging from the use of electrical energy, in general, urban areas will be higher than rural areas. However, from a tourism perspective, the energy consumption required may be much greater. This has not been added to the number of vehicles that enter tourist areas and the emergence of both organic and inorganic waste from tourism activities. Further research is expected to quantify the magnitude of GHG emissions generated from the tourism sector.

Acknowledgements
This paper is supported by grant of “Desa Binaan” by Directorate of Community Service Universitas Gadjah Mada in 2021, contract number 312/UN1/DPM/YANMAS/PM/2021

References
[1] Rhodes CJ 2016 The 2015 Paris climate change conference: COP21. Sci. Prog. 99 97–104
[2] United States Agency for International Development – USAID 2018 Climate Risk Profile Indonesia (New York: USAID).
[3] Sekaranom AB, Suarma U and Nurjani E 2020 Climate extremes over the maritime continent and their associations with Madden-Jullian Oscillation IOP Conference Series: Earth and Environmental Science 451 12006
[4] Marfai MA, Sekaranom AB and Ward P 2015 Community responses and adaptation strategies toward flood hazard in Jakarta, Indonesia. Nat. hazar. 75 1127–44.
[5] Sekaranom AB, Nurjani E, Harini R and Mutaqin AS 2020 Simulation of Daily Rainfall Data using Articulated Weather Generator Model for Seasonal Prediction of ENSO-Affected Zones in Indonesia. Indones. J. Geogr. 52 143–53.
[6] Sekaranom AB, Nurjani E, Hadi MP and Marfai MA 2018 Comparison of TRMM Precipitation Satellite Data over Central Java Region-Indonesia Quaest. Geogr. 37 97–114.
[7] Sekaranom AB and Masunaga H 2019 Origins of heavy precipitation biases in the TRMM PR and TMI products assessed with cloudsat and reanalysis data J. Appl. Meteorol. Climatol. 58 37–54.
[8] Jourdain NC, Gupta A Sen, Taschetto AS, Ummenhofer CC, Moise AF and Ashok K 2013 The Indo-Australian monsoon and its relationship to ENSO and IOD in reanalysis data and the CMIP3/CMIP5 simulations Clim. Dyn. 41 3073–102
[9] Sekaranom AB, Nurjani E, Harini R and Mutaqin AS 2020 Developing SIMASTI to disseminate information of season prediction and prepare for adaptation strategies in agriculture to climate change IOP Conference Series: Earth and Environmental Science 451 012005
[10] Van Der Werf GR, Dempewolf J, Trigg SN, Randerson JT, Kasibhatla PS, Giglio L, et al. 2008 Climate regulation of fire emissions and deforestation in equatorial Asia Proc. Natl. Acad. Sci. 105 20350-55
[11] Christoff P 2016 The promissory note: COP 21 and the Paris Climate Agreement. Env. Polit. 25 765–87
[12] Djalante R, Thomalla F, Sinapoy MS and Carnegie M 2012 Building resilience to natural hazards in Indonesia: Progress and challenges in implementing the Hyogo Framework for Action Nat. Hazar. 62 779-803
[13] Leichenko R 2011 Climate change and urban resilience Curr. Opin. Environ. Sustain. 3 164–8
[14] United States Agency for International Development – USAID 2016 Indonesia: Costs of Climate Change 2050 (Washington DC: USAID)