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Utilization of Meso-scale Weather Models in Urban Development Policy and Planning: A Review

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ABSTRACT: The policy in dividing the KBI and KTI regions is intended to avoid development imbalances that occur in Indonesia. Development in Eastern Indonesia is considered disproportionate and only focused on the Western Region. But now the priority of regional development will be focused on Eastern Indonesia. As a large city in North Sulawesi that is included in Eastern Indonesia, Manado has a strategic location as an investment gateway to economic growth in Eastern Indonesia, this is the background for the development plan of Mapanget sub-district which is included in the Manado City area to become a new city center. This research aims to assess the feasibility of the Mapanget area as the object of this strategic project. The method used was a literature study in combination with the availability of secondary data obtained from research, records and provisions related to the analysis of new city development. Based on the results of the various elements of new city development such as residential areas, health and education facilities, trade, services and industry, and population accessibility have experienced large growth in the period (2007-2019) or in the last twelve years. In terms of development planning, there are also complete guidelines that are based on an in-depth study of various aspects, so it can be concluded that Mapanget Sub-district is strategic enough for the development of a New City in Eastern Indonesia.

Keywords: Urban, Regional Planning, Climate Change, Weather Model, WRF

INTRODUCTION

Development planning in urban areas should ideally consider weather and climate factors. In the past, climate change was only seen as an impact or side effect of development, but now climate change must take a role in determining policies and development planning in urban areas. This is not without reason, the development that occurs in big cities affects weather and climate conditions exponentially (Colavitti & Serra, 2021; Granberg et al., 2019; Mell, 2020). Meanwhile, the impact of climate change itself is most felt by people living in urban areas (Darmanto et al., 2019; Rakuasa et al., 2023). Urban problems that can arise due to climate change include: flooding (KC et al., 2021; Rakuasa & Pertuack, 2023), sea level rise (Irawan et al., 2021), increased air temperature, decreased water quality (Luo et al., 2019), deteriorating air quality (Kim et al., 2021)

and various health problems (Latue & Rakuasa, 2023). To overcome this, the government must try to implement concrete actions.

Over the past few years, environmental issues have been at the top of the policy agenda in both developed and developing countries. The Government of Indonesia has recently launched the first 'green' National Medium-Term Development Plan (RPJMN 2020-2024) that includes Low Carbon Development and Climate Resilience as one of the National Priorities. This is a result of the review of the National Action Plan - Climate Change Adaptation (RAN-API) in the 2015-2019 RPJMN. Previously, the Government of Indonesia had issued Presidential Decree No. 61/2011 on the National Action Plan for Reducing Greenhouse Gas Emissions (RAN-GRK). The RAN-GRK target is to reduce GHG emissions below the baseline in 2020 by 29%, and the target in 2030 is 41%.

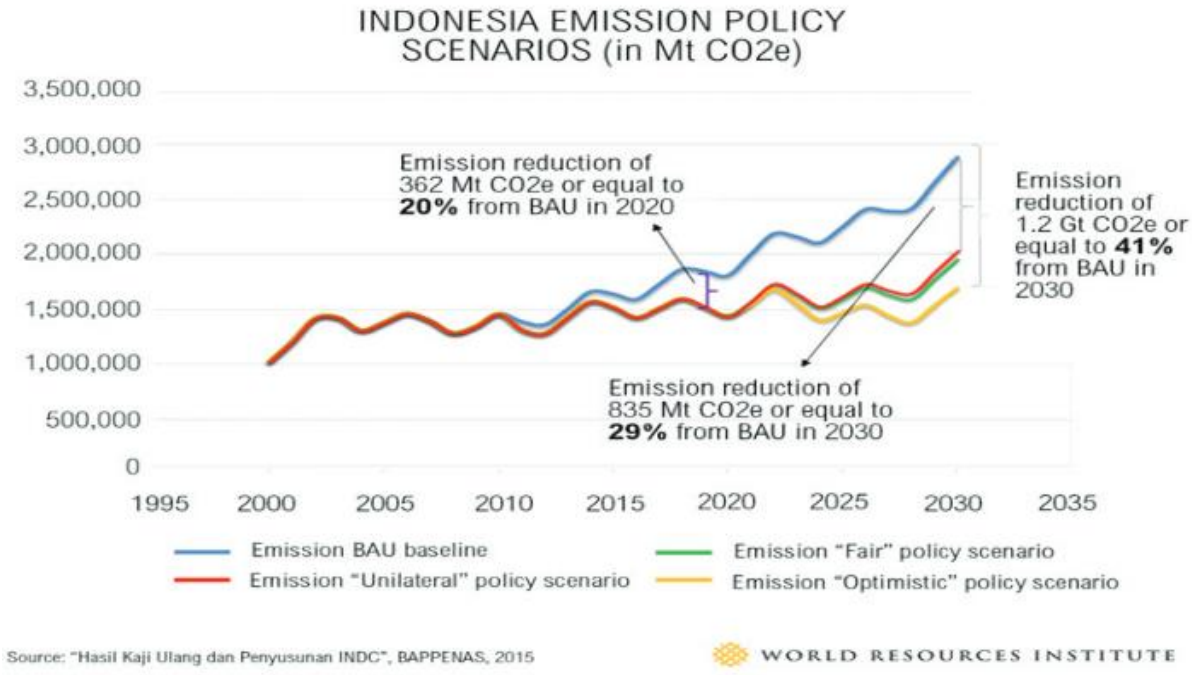

Figure 1. RAN-GRK emission reduction scenarios
Source: (Legionosuko et al., 2019)

However, the emission reduction strategy through the RAN-GRK still focuses on reducing emissions from forest fires (Table 1). In fact, urban areas contribute 89% of CO2 gas emissions through transportation. For this reason, it is necessary to organize and manage urban areas by considering climate change scenarios. So that the achievement of GHG emission reduction targets as an effort to mitigate and adapt to disasters due to climate change can be achieved immediately.

Table 1. GRK Emission Reduction Target per Sector

Sector	Emission Reduction Plan (Giga Ton Co2e)		Action Plan	Implementing Ministries/Institutions
	26%	41%		

Forestry & Peatland	0,7672	1,039	Control of forest & land fires; Management of water networks & soil systems; Forest & land rehabilitation, HTI, HR; Eradication of illegal logging; Prevention of deforestation; Community empowerment	Ministry of Forestry, Ministry of Environment, Ministry of Public Works, Ministry of Agriculture
Agriculture	0,008	0,011	Low-emission rice variety instruction, irrigation water efficiency, organic fertilizer use	Ministry of Agriculture, Ministry of Environment, Ministry of Public Works
Energy & Transportation	0,038	0,056	Use of biofuels, engines with higher fuel efficiency standards, improving TDM, quality of public transportation and roads, demand side management, energy efficiency, development of renewable energy, etc.	Ministry of Transportation, Ministry of Energy and Mineral Resources, Ministry of Public Works, Ministry of Environment
Industry	0,001	0,0005	Energy efficiency, use of renewable energy, etc.	Ministry of Agriculture, Ministry of Environment
Wastes	0,046	0,076	Landfill development, 3R waste management, and integrated wastewater management in urban areas	Ministry of Public Works, Ministry of Environment
	0,767	1,1689		

Sumber: (BAPPENAS, 2019)

Efforts to reduce GHG emissions in urban areas can be done by planning and structuring an ideal city through the concept of green planning. Green Planning is the realization of spatial planning and urban design based on the environment. In the preparation of spatial plans and urban design, it must be in accordance with applicable laws and regulations and implemented continuously and synergistically between planning, utilization and control of spatial utilization. Efforts to raise public awareness and realize the sustainability of urban life, among others, can be done in the form of the realization of the Green City (Greencity).

An overview of climate projections and urban planning can be done by utilizing models. Along with the development of technology, urban modeling can no longer only be done by developed countries. Urban modeling can be done by utilizing open source software. The advantages of open source models are: flexible, lightweight and free of charge. One of the models that can be used is Weather Research and Forecasting (WRF). This model is very commonly used in Indonesia, especially in the field of meteorology. The Meteorology, Climatology and Geophysics Agency (BMKG) has used the WRF model for its daily operations in predicting the weather. However,

this model is not only capable of predicting weather. But it can also be used to predict urban effects on atmospheric conditions, so that it can be utilized for urban development planning by considering climate factors. In this research, we will further study the utilization of the WRF model in the field of urban development planning, especially in Indonesia.

METHOD

This research was conducted using a qualitative method by collecting various references on urban modeling for urban development planning. Research such as that conducted by Papangelis et al., (2012) utilized the Weather Research and Forecasting (WRF) model for "green" urban planning in Athens, Greece. The study used WRF version 3.1.1. WRF is a meso-scale numerical model used for weather condition prediction and atmospheric simulation by integrating Advanced Research (ARW) dynamic modeling (Skamarock et al., 2019). The study of WRF modeling for the purposes of planning and simulating atmospheric conditions in urban areas has experienced an increasing trend in the last 10 years (Kwok & Ng, 2021). The WRF model is generally widely used in developing countries due to its open source nature, making it easy to obtain.

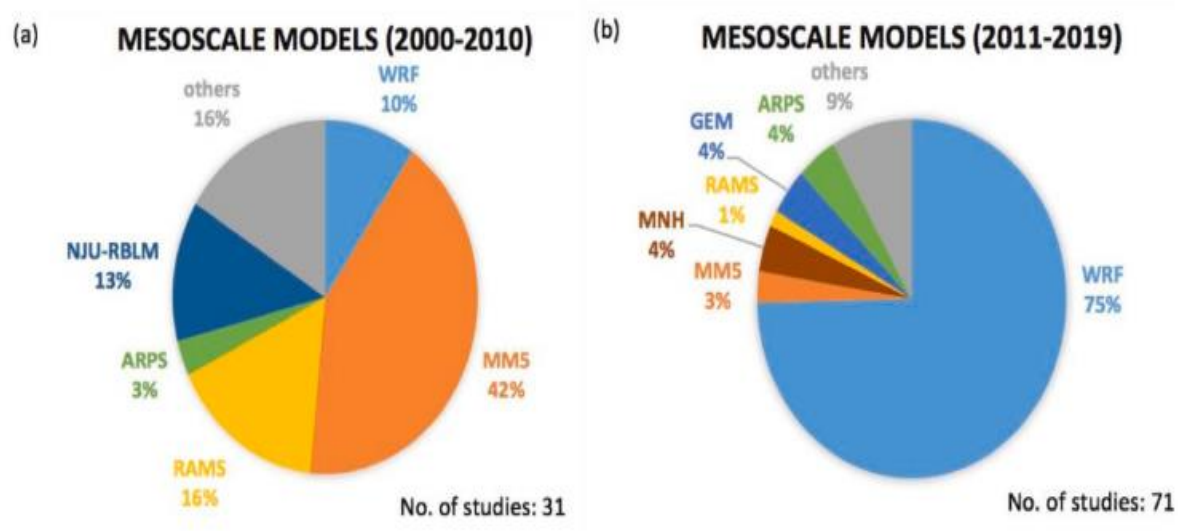

Figure 2. Statistics on the use of the meso-scale atmospheric model during the years (a) 2000-2010 and (b) 2011-219
Source: (Kwok & Ng, 2021)

The discussion in this study is limited to the utilization of the WRF meso-scale model in the study of the influence of urban areas on atmospheric conditions and also in the field of urban development planning, especially in Indonesia.

RESULT AND DISCUSSION

Understanding the impacts of urban areas on atmospheric processes is important in finding a scientific basis for addressing climate change issues in urban areas. Results from urban studies can also be used to design urban development plans and inform government policies (Hidalgo et al., 2019; Hehanussa et al., 2023). Simulations conducted in the city of Athens, Greece showed that an urban park of 8 m2 built in an industrial/commercial area can reduce temperatures by > 5oC

at night. The park in this urban area can form a "cold pool" at night that blows cold air throughout the city at night in a range almost equal to the area of the park.

Another study in Singapore produced mitigation scenarios to reduce the impact of urban heat islands (UHI) in tropical city areas. The results of the study show the importance of reducing building density in the Singapore urban area. As well as to be able to reduce the air temperature by 1.3oC on the surface, a cool roof design is used. Cool roof refers to roof designs in urban areas with high surface reflectance. This roof absorbs less incoming radiation. This method can reduce the temperature inside the building thereby reducing the use of cooling energy such as air conditioning (Mughal et al., 2020) . The results of the synthesis previously carried out by Kwok & Ng, (2021), show that most of the discussion topics for urban area modeling studies are related to UHI. The rest is Land Cover (LC), Urban Surface Energy Balance, Urban Planning, Air Quality, Rain, Heat Stress, Energy Consumption and others.

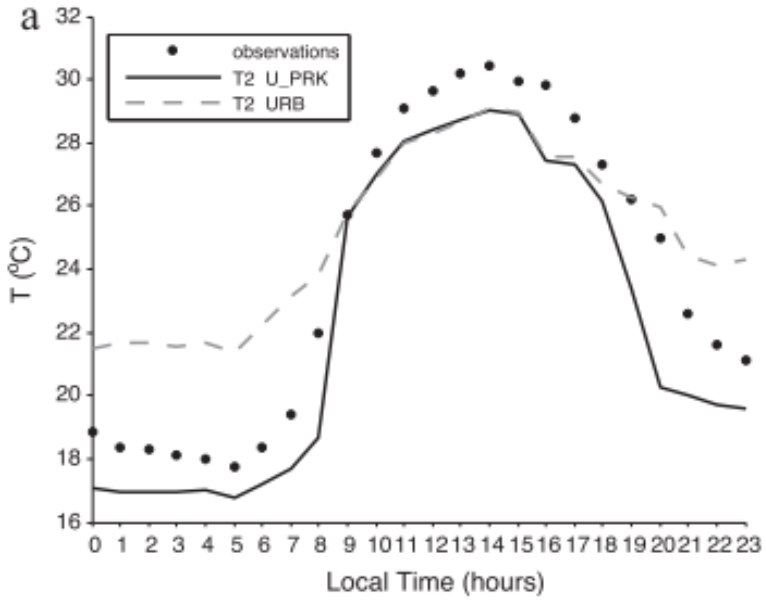

Figure 3. Comparison of daily air temperature variations observed (observation); without scenario (URB) and with park scenario (U_PRK).
Source: (Papangelis et al., 2012)

The utilization of the WRF model to assess the impact of urban areas in Indonesia is still limited. In general, WRF is used to determine the impact of the Urban Heat Island (UHI) effect in urban areas. However, existing studies are still limited to simulating atmospheric conditions, not yet providing recommendations for urban design and regional development planning (Blackstone et al., 2017; Bonnett & Birchall, 2023; Harbin & Larsen, 2017; Lamberg, 2021). Most studies are also still focused on the capital city of Jakarta (Fatkhuroyan et al., 2019; Hastuti & Paski, 2019). The effect of UHI on rainfall in Makassar city has been conducted by Sari & Atsidiqi (2020). Research involving climate change scenarios using the WRF model in the Indonesian region was recently conducted by (Darmanto et al., 2019). The research was conducted in the Jakarta area using the WRF model couple with the Single Layer Urban Climate Model (SLUCM) model. The rest, urban area studies are generally carried out using observational data or weather observations.

CONCLUSION

Policy and Planning Regional development by utilizing the results of WRF numerical weather model simulations has now been carried out in many countries. Model simulation results can be used as recommendation material for the government in determining urban design and determining urban planning policies. However, from the results of the literature review, the utilization of the WRF model in Indonesia is currently still limited to studies. It is expected that in the future, the use of numerical models will be increasingly carried out and utilized in urban planning even to the design of regional development policies in Indonesia.

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