



Classification of air pollution problems in Southeast and South Asia using time-series data on environment, society, and governance

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Abstract : Air pollution problem is one of the most health-damaging environmental problems that causes millions of premature deaths each year. This study focuses on public air pollution-related awareness, which is considered a driving force to improve environmental problems. We classified 8 Asian megacities into 3 classes by the trends of environmental pollution, public pollution-related awareness, and public mitigation policies. It was found that there are common characteristics among the countries in each class. In countries with high democracy index value, public pollution-related awareness may have been reflected in public mitigation policy. In contrast, ground swell to improve air quality may have not been reflected in policy making well in countries with low democracy index value. These results imply that the stage of air pollution problem in country differs by not only environmental pollution and GDP per capita but also public pollution-related awareness and legal system in countries.

1. Introduction

- Air pollution comprises 11.65% of total death rate in the world (IHME, 2021).
- PM_{2.5} is the most health-damaging air pollutant which causes 10.2 millions of premature deaths every year (Vohra et al., 2021).
- Asian megacities experience intensive air pollution especially caused by PM_{2.5} (Fig.1,2).

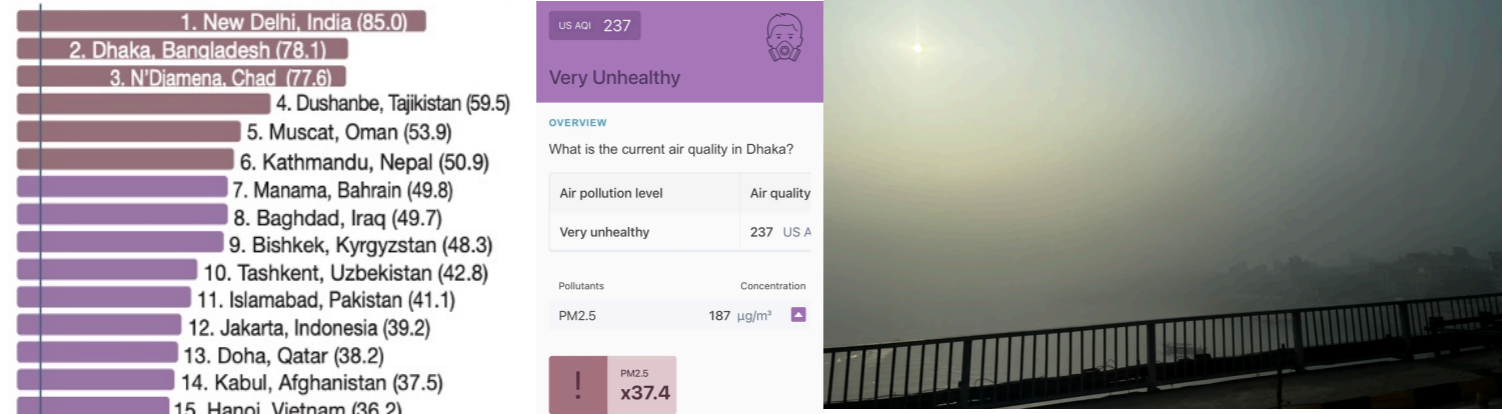


Fig.1 PM_{2.5} concentration in capital (Blue : WHO guideline)

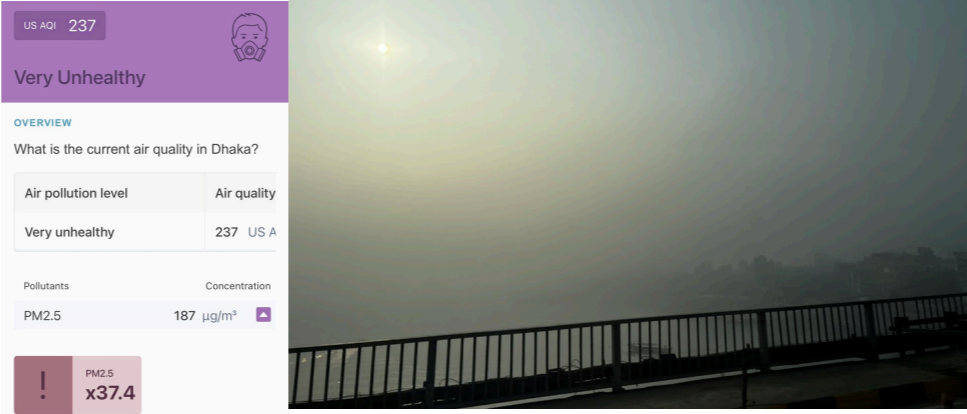


Fig.2 Poor air quality in Dhaka, Bangladesh (Dec 10th, 2023)

- Past study on Environmental Kuznets Curve revealed relationship between GDP per capita and environmental degradation (Fig.3).
- It is assumed that improvement of air quality can be attributed to reduction effects by legal system and public desire to obtain superior goods such as better environment (Morrissey, 2000).

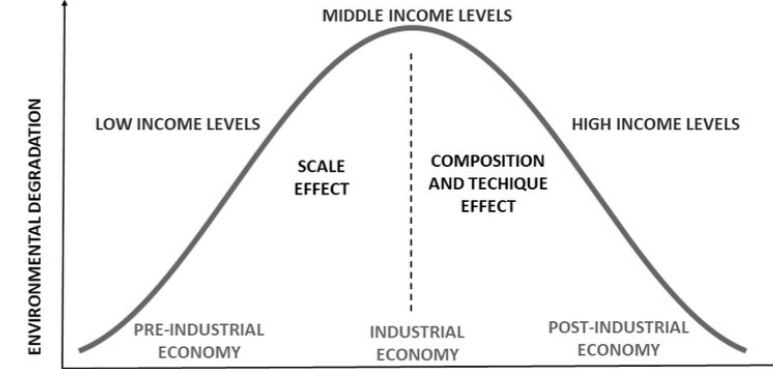


Fig.3 Conceptual diagram of Environmental Kuznets Curve (Mitić et al., 2019)

2. Methodology

Research objective

- Grasp of stages of air pollution problems in Asian countries considering not only environment but also society and governance.
- Development of a method to partially complement the lack of cross-country dataset on society.

Originality

- Cross-country analysis using homogenous time series data on environment, society, and governance.
- Acquisition of insight of common features among environment, society, and governance in each stage on air pollution problems.

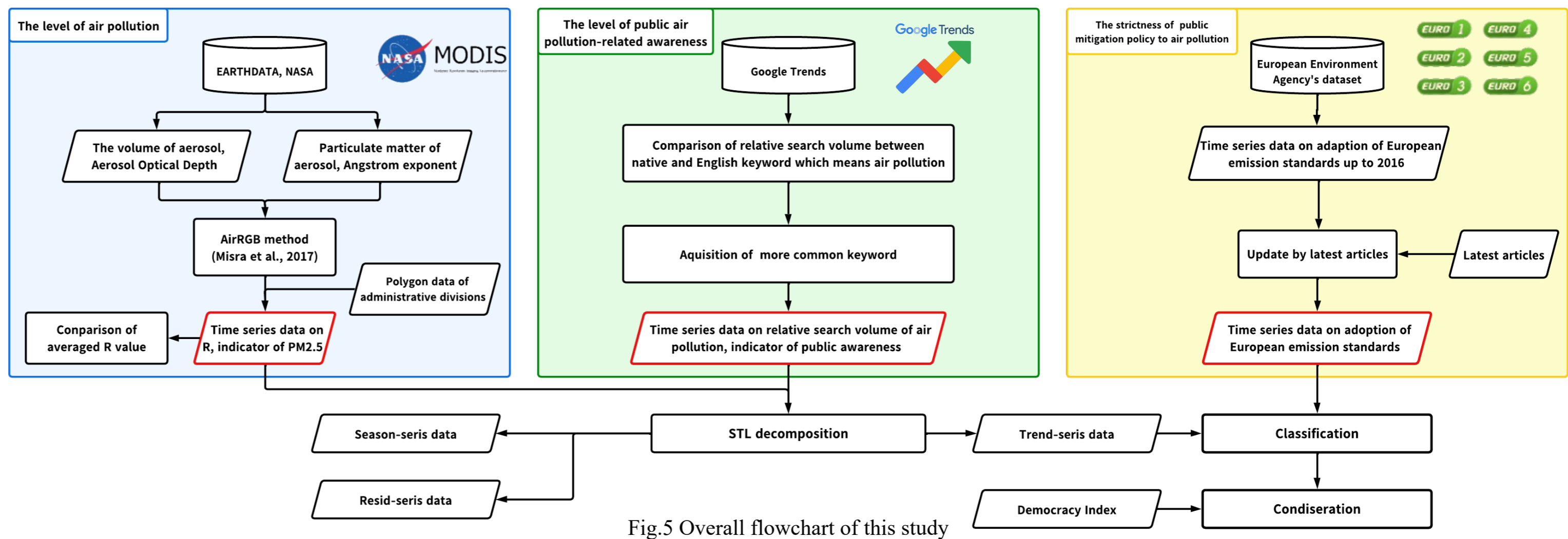


Fig.4 Study area, Southeast and South Asian megacities populated by over 5 million people in 2010

Table 1. Adoption of European emission standards in study area

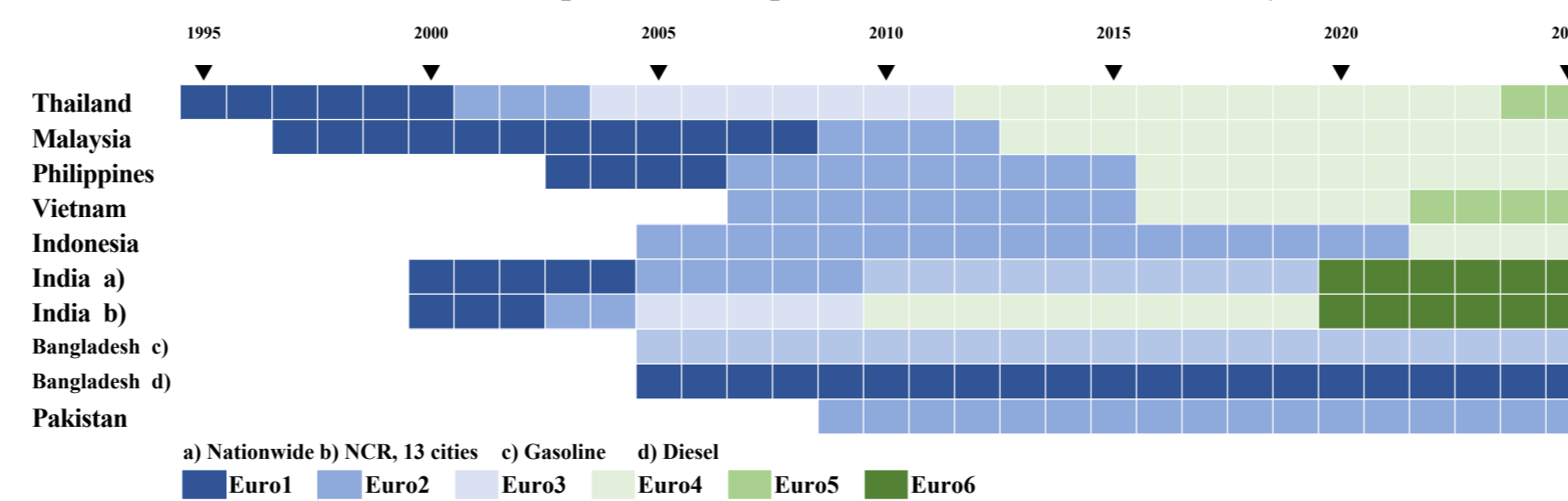


Table 2. Democracy index value of study area in 2020

Region	Nation	Democracy index
Southeast Asia	Indonesia	6.30
	Philippines	6.56
	Thailand	6.04
	Vietnam	2.94
	Malaysia	7.19
South Asia	India	6.61
	Pakistan	4.31
	Bangladesh	5.99

3. Results

Table 3. Comparison of R, indicator of PM_{2.5} concentration among various megacities

Region	Nation	Megacity	R mean	R sd
Southeast Asia	Indonesia	Jakarta	44.0	16.2
	Philippines	Mamila	22.6	8.4
	Thailand	Bangkok	46.4	17.6
Asia	Vietnam	Ho Chi Minh	47.9	14.0
	Malaysia	Kuala Lumpur	35.0	16.7
	India	Delhi	40.2	20.4
	Pakistan	Karachi	9.6*	10.3
	Bangladesh	Dhaka	48.1	19.0
Western Europe	France	Paris	6.7	10.2
	United Kingdom	London	7.7	8.9
North America	Germany	Hessen-Düsseldorf	5.7	4.4
	United States	New York	4.7	4.8
	Canada	Toronto	4.4	5.5

* Underestimation of R in desert area such as Karachi

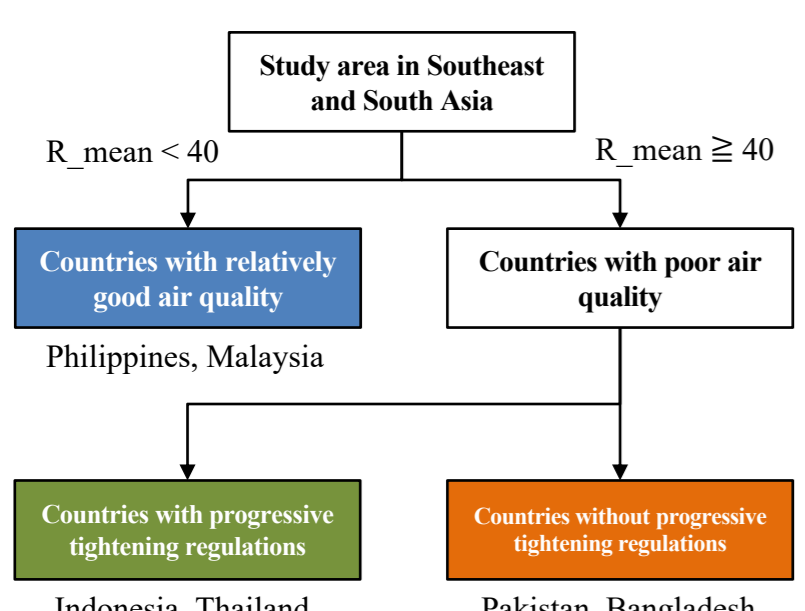


Fig.6 The result of classification into 3 classes for each study areas

Class 1 : Countries with relatively good air quality

- Features

 - Relatively good air quality
 - decreasing trend of public air pollution-related awareness
 - Recent stagnation of introduction of stricter regulations
 - High democracy index value

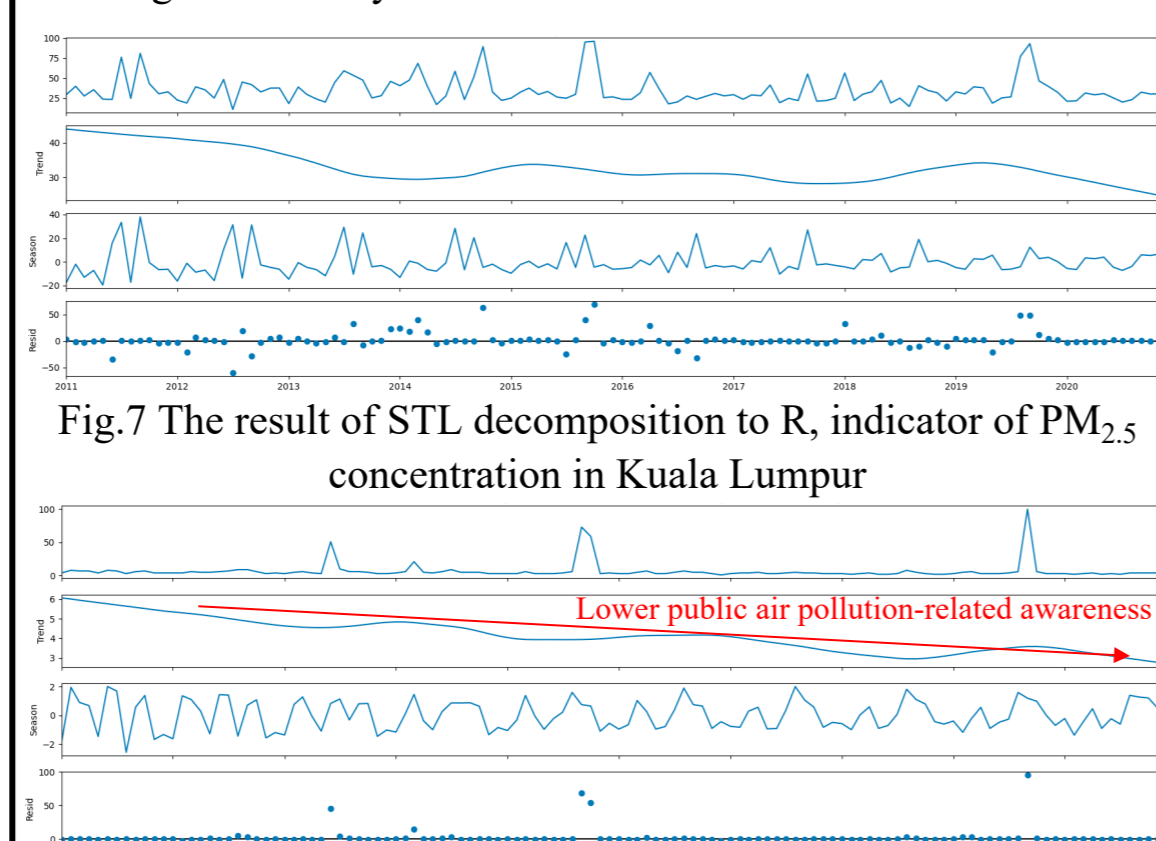


Fig.7 The result of STL decomposition to R, indicator of PM_{2.5} concentration in Kuala Lumpur

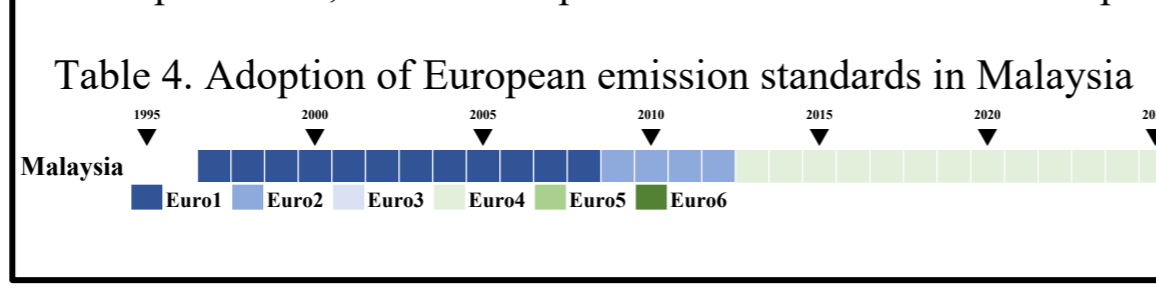
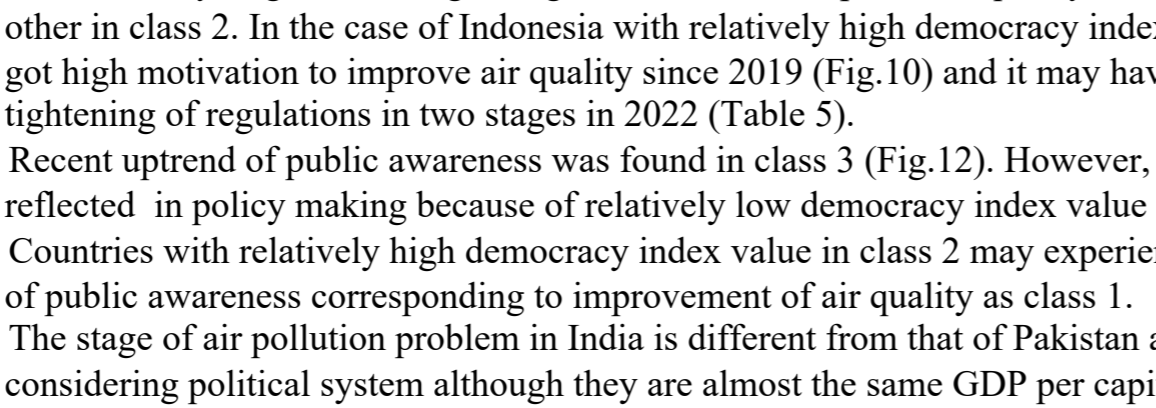


Fig.8 The result of STL decomposition to relative search volume of "air pollution", indicator of public awareness in Kuala Lumpur

Table 4. Adoption of European emission standards in Malaysia



Class 2 : Countries with progressive tightening regulations

- Features

 - Poor air quality
 - Recent uptrend of public air pollution-related awareness
 - Introduction of stricter regulations

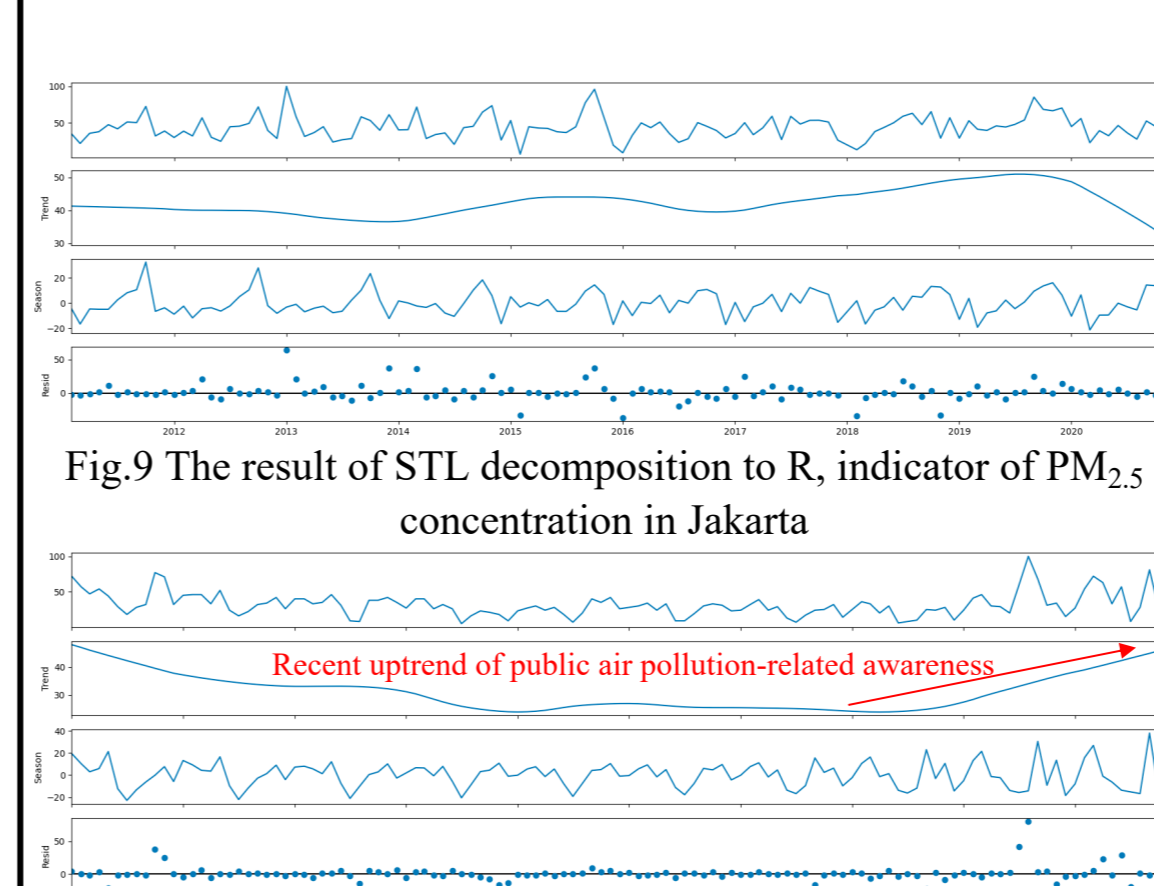


Fig.9 The result of STL decomposition to R, indicator of PM_{2.5} concentration in Jakarta

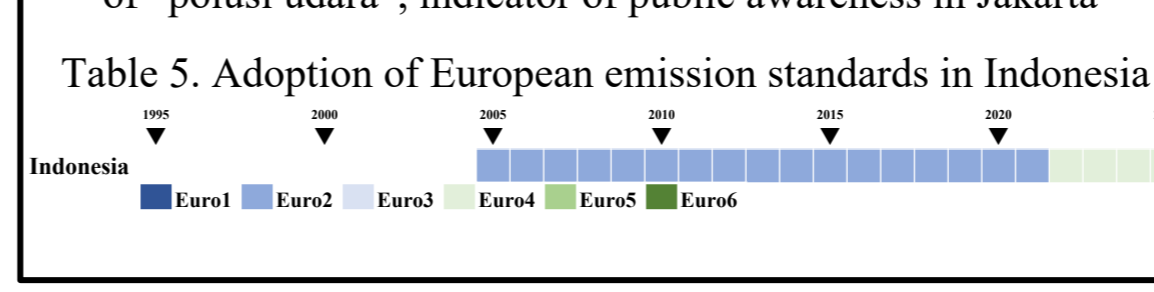
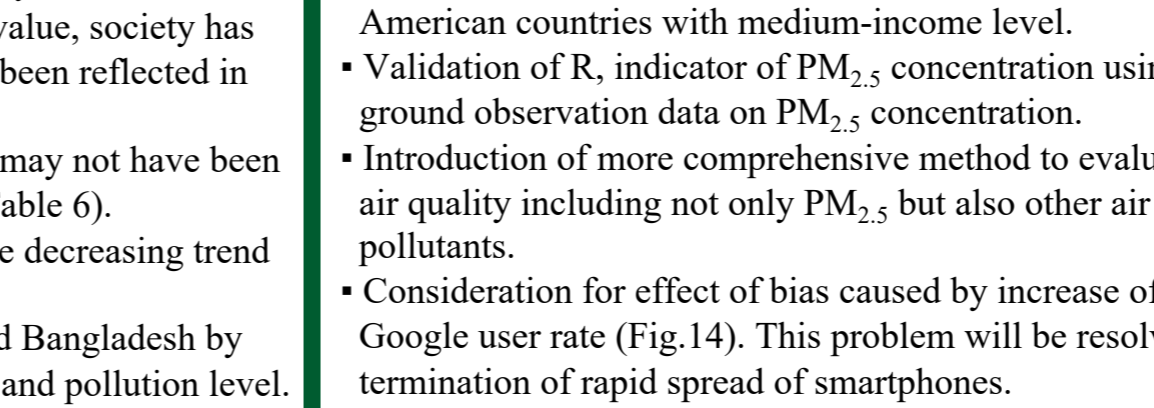


Fig.10 The result of STL decomposition to relative search volume of "polusi udara", indicator of public awareness in Jakarta

Table 5. Adoption of European emission standards in Indonesia



Class 3 : Countries without progressive tightening regulations

- Features

 - Poor air quality
 - Recent uptrend of public air pollution-related awareness
 - Stagnation of introduction of stricter regulations
 - Relatively low democracy index value

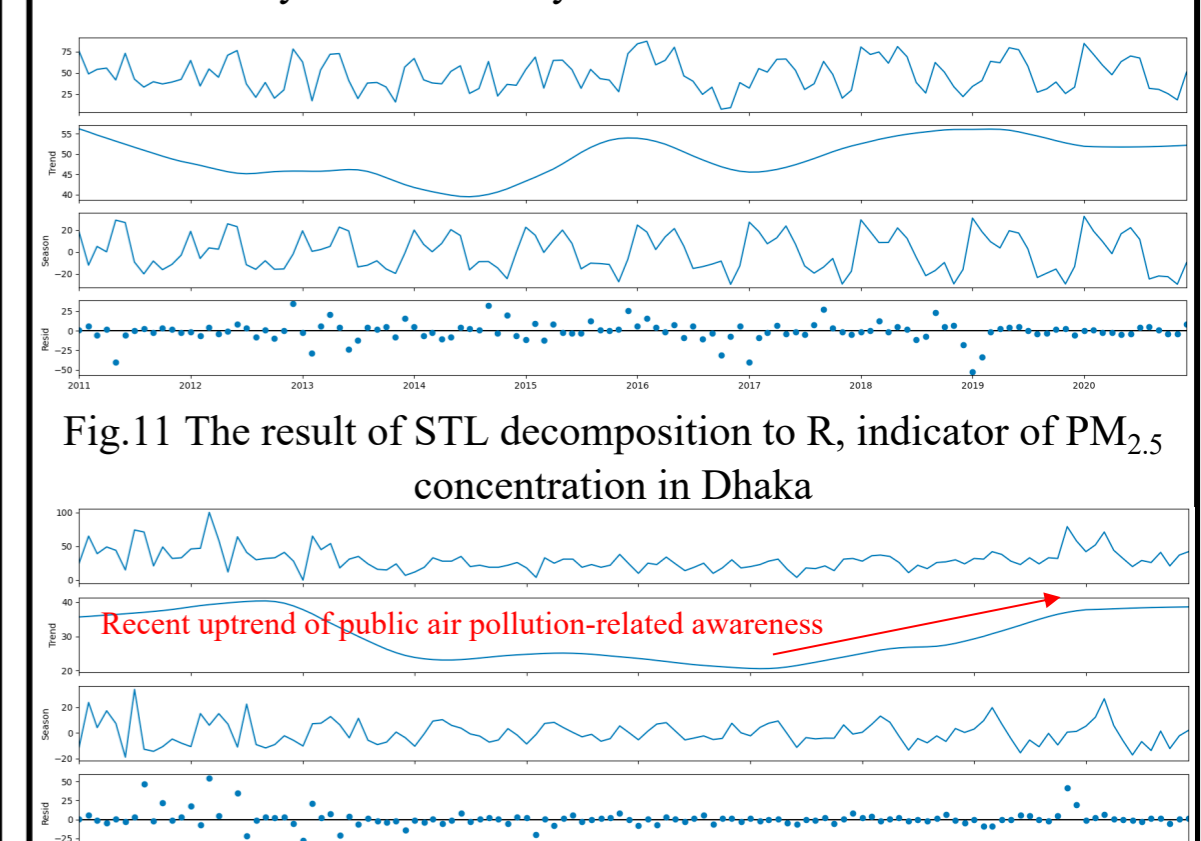


Fig.11 The result of STL decomposition to R, indicator of PM_{2.5} concentration in Dhaka

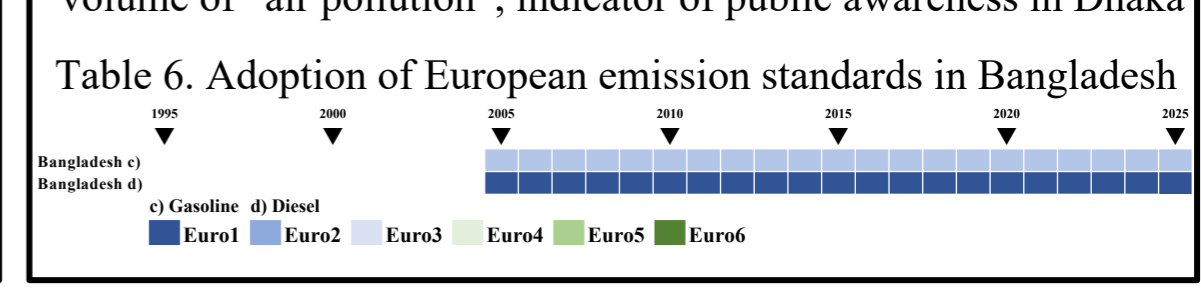
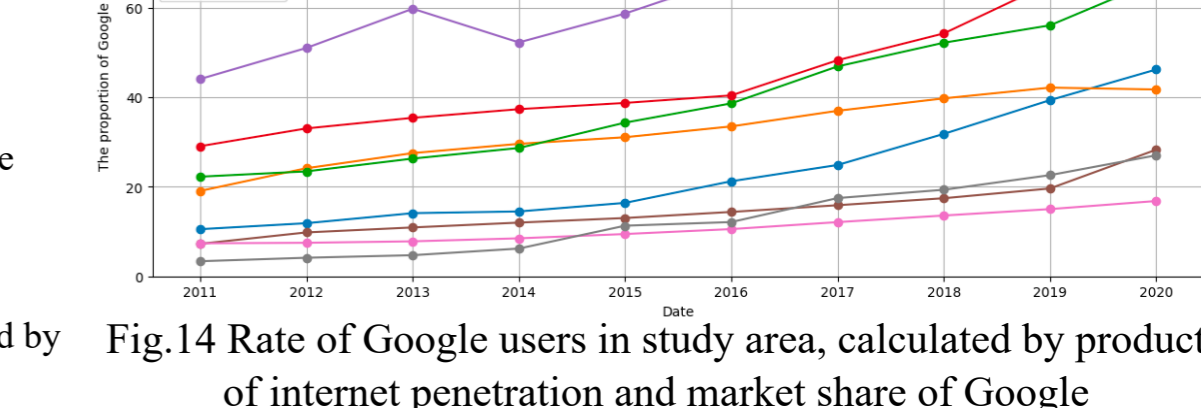
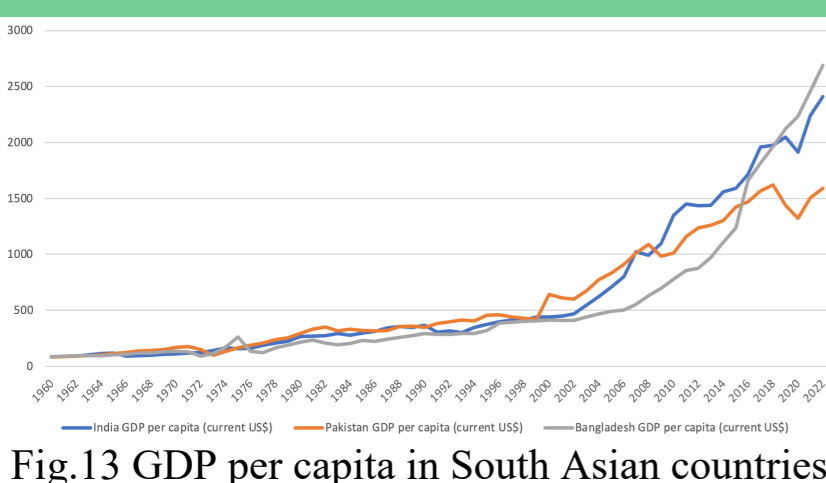


Fig.12 The result of STL decomposition to relative search volume of "air pollution", indicator of public awareness in Dhaka

Table 6. Adoption of European emission standards in Bangladesh



4. Discussion



Improvement of air quality can lead lower public air pollution-related awareness (Fig.8). It may have been reflected in stagnation of installation of stricter regulations (Table 4) in class 1 with high democracy index value. Either society or governance gets high motivation to improve air quality and may stimulate the other in class 2. In the case of Indonesia with relatively high democracy index value, society has got high motivation to improve air quality since 2019 (Fig.10) and it may have been reflected in tightening of regulations in two stages in 2022 (Table 5). Recent uptrend of public awareness was found in class 3 (Fig.12). However, it may not have been reflected in policy making because of relatively low democracy index value (Table 6). Countries with relatively high democracy index value in class 2 may experience decreasing trend of public awareness corresponding to improvement of air quality as class 1. The stage of air pollution problem in India is different from that of Pakistan and Bangladesh by considering political system although they are almost the same GDP per capita and pollution level.

5. Future work

- Additional empirical analysis in Middle Eastern or South American countries with medium-income level.
- Validation of R, indicator of PM_{2.5} concentration using ground observation data on PM_{2.5} concentration.
- Introduction of more comprehensive method to evaluate air quality including not only PM_{2.5} but also other air pollutants.
- Consideration for effect of bias caused by increase of Google user rate (Fig.14). This problem will be resolved by termination of rapid spread of smartphones.

