POVERTY AND ENVIRONMENT NEXUS:
Evidence from Indonesia

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"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

(Brundtland 1987)

Dorus Rijkersplein room 47,
August 22, 2013
03.36 am

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List of Acronyms

HDI	Human Development Index
MEA	Millennium Ecosystem Assessment
UNDP	United Nations Development Programme

Abstract

Poverty and environment problems are often threated separately as an individual problem. However, there is huge of facts that the poor collectively could not be apart from the environment. Thus, several channels have been employed in this paper in order to investigate in which poverty and environment are associated. Those are livelihood, health and vulnerability links. Using a panel data set of 32 provinces ranged from 2001 to 2010, this study provides evidences on poverty and environment nexus by employing various methods. The findings verify: (a) high correlation on rural poverty rate and forest coverage; (b) weak correlation on rural poverty density and forest coverage. This paper also confirms on causality testing that results in non-bidirectional causalities. Rather, evidently it is causal relationship from rural poverty to forest. In order to find the nexus in each province, poverty-environment indices were constructed and result in various degree of poverty-environment vulnerability. Specifically, performance for each province across time also has been examined and results also in various poverty-environment vulnerability reductions. Finally, additional result on poverty-environment vulnerability and HDI relationship has given a meaningful insight that higher HDI constitute lower poverty-environment vulnerability.

Relevance to Development Studies

Recently, a growing literature has been acknowledged that the poor and the environment are interconnected. Some believe that poverty and environment act as a vicious circle while others argue a different non-vicious relationship. The contention has lead many studies to find the link between forested land and rural poverty. However, little is known about the direct causality between them. This study is supposed to fill the gap by exploring the causal direction of rural poverty rate and forest coverage in Indonesia context. The findings of the study are expected to have importance in informing for policy decision-making on poverty alleviation and forest conservation.

Keywords

Rural poverty rate; rural poverty density; forest coverage; Indonesia

Chapter 1
Introduction

1.1. Introduction

Human development and environmental issues have generally been articulated separately as an individual issue (Nunan et al. 2002). Many scholars have focused on poverty for decades since this is an impediment for economic development. However, the debates on poverty reduction often concentrated in the concept of poverty and its measurement methods (Comim et al. 2009). On the other hand, environmental issues such as water scarcity and forest degradation are also taken seriously as important environment problems. In fact, there are some evidences that people living in poverty often suffer from lack of clean water and have less access to clean energy. Hence, it is a hard task to solve these problems without acknowledging them altogether (DFID et al. 2002).

Based on that, it is important to single out the role of environment into the broader concept of poverty or the way around. Millennium Development Goals has developed poverty reduction targets through emphasizing the role of environment. Besides, Millennium Ecosystem Assesment (2005) has also bridged the concept of ecosystem and human well-being. It has identified the link between environmental change into human well being through ecosystem services such as fresh water and timber or solid fuel. Lack of access to safe water supplies and lack of adequate sanitation has been the main reason for poor people to suffer from water-associated infectious (ibid:2). Similarly, lack access to clean energy source for cooking foster poor people to use solid fuel that will lead them to suffer from respiratory disease due to indoor air pollution exposure (ibid:3). Although the linkages between poverty and environment are now highly explored, however the relationship remains far from conclusions (Forsyth et al. 1998).

Although many literatures have recognized the connections between poverty and environment, however, a significant amount of literatures still present a contention on this issue. To start from a conventional wisdom coming from the Bruntland Comission report, says poverty is a major cause of environmental degradation (as cited in Aggrey et al. 2010). Another general consensus is Neo-Malthusian. This views the nexus through poverty-population-environment spiral; the poor tend to have more children, as they are concern about extra labour and income. This situation in turn will foster higher pressure on environment since their livelihood depends on environmental services and then will lead them to be more impoverished (Fischer 2010)[1].

Moreover, Prakash (1997) observes several conditions in which poverty might be or might not be a cause of environmental degradation. By considering short time horizon

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[1]Fischer (2010) also provides a counter argument that poor people could be modernized demographically but remains poor economically.

and risk taking, poor people might cause degradation. They tend to have low resilience to risk and respond to external shock by degrading the environment to get quick and easy alternative income. Further, under certain poverty conditions, the poor tend to have high family sizes, which in turn results in more pressure to environment.

In spite of research findings and conceptual changes, Brundlant Comission report and Neo-Malthusian perspective still largely dominate public dialogue on poverty-environment nexus. Although most studies have used huge observations such households to look at how poverty-environment interacts with each other, however, the conclusion remains varied. This debate between pubic knowledge, methods and research findings suggests the need of further empirical research examining on the extent of poverty interact with environment.

Evidently, poverty and environment problem are both prevalent in Indonesia. In view of this, number of the poor in rural Indonesia, where peoples are more dependent on environment for their livelihood, is about twice compared to urban poor. In addition, poverty is more prevalent in rural areas than in urban areas. IFAD (2013) stated that 16.6 per cent of rural people are poor while urban poor is only 9.9 per cent. Moreover, there are around twenty million people living in or near the forest (Sunderlin et al. 2000). Since relatively rural people's livelihood depends more on natural environment than urban people do, thus it provides meaningful insight that rural poor and physical environment might be more connected. This study therefore has attempted to find out the interconnection between poverty and environment. What is the poverty environment nexus in Indonesia context and how they are interconnected to each other are the basic questions of this study.

1.2. Statement of the problem and justification

Nexus between poverty and environment is complex; therefore, understanding the nexus needs a strategic line of thought. Numbers of literatures have mainly focused on the "vicious circle" of poverty and environment link (Reardon and Vosti 1995). The circle assumes that poverty causes environmental degradation and deteriorating environmental condition leads the poor to be more impoverished. On the one hand, poverty is a determinant of environmental degradation. From this discourse, it is argue that: (1) poor people are concentrating in less favorable or fragile land (Barbier 2008, Barbier 2010). Evidence from Lao PDR also says that poverty has positive correlation with fragile land (Dasgupta et al. 2005); (2) the role of environmental resources in the share of aggregate income of the poor is strong (Cavendish 2000, Vedeld et al. 2007, Kamanga et al. 2009, Hogarth et al. 2012). That is the environmental income comes from timber harvesting, fuel wood extraction, charcoal, or smoothing consumption through fruit harvesting etc.

On the other hand, poor environmental condition is also a determinant of poverty (Shyamsundar 2002). From that study, the environment affects the poor through two channels: environmental condition that impact health of the poor and natural resources condition that affect living condition of the poor. The health effect of polluted water, for instance, is the spread of disease such as diarrhea, malaria, and respiratory infection. Duraiappah (1996) also stated that the prevalence of diarrhea is a leading cause of child and infant mortality. Furthermore from the second channel, natural resource problems such as land degradation, natural disaster, and water scarcity could influence the poverty through affect their income, food security and vulnerability to natural disasters.

Another example of poverty and environment nexus is also raised in Africa. On the one hand, environmental damage such as deforestation, land degradation and limited water supply worsens the condition of the poor; on the other hand, due to lack of adequate land foster poor people to convert natural resources to get access into agricultural land (Lufumpa 2005). Further, a study conducted in Peru shows that using panel data of household survey has tried to prove empirically the relationship between household income and land clearing decision (Zwane 2007). However, the paper failed to accept that land-clearing decision depends negatively on household income. Rather it is depending upon household size due to imperfect labor market. From these two cases, the theory of relationship of income and land clearing is ambiguous. Another issue from Latin America suggests that not only the poor is responsible for the ongoing natural resource depletion but also the non-poor. While the poor suffer from investment poverty, the non-poor and the poor suffer from incentives distortions due to environmental externalities (Swinton et al. 2003).

Despite huge researches have been done to find out the pattern of the prevalence link between poverty and environment, however, there are few studies that elucidate the causal relations of poverty and environment. The research paper, therefore, aimed to understand the poverty environment nexus in Indonesia using different definition of poverty and environmental degradation approaches and methods. In this respect, it is hoped that the paper will add to the existing literature and also offer further insight in understanding the poverty environment nexus.

1.3. Research questions

The study is aimed to answer the following questions:

Main question**:** How poverty indicators are interconnected into environment indicator?

Sub questions**:**

1. Is poverty indicator independent with environmental indicator?
2. If it is (not), is there any causality between them?
3. Does the poverty environment nexus vary across province and over time?

1.4. Basic line of thoughts or Hypothesis

We hypothesized that:

- Poverty and environment are an integrated problem. Thus, it is expected that between poverty and environmental keys indicators are inter-connected.
- Poverty and environment nexus are often believed as a vicious circle. Thus, it is expected that between poverty and environment indicators have strong causality.

- Poverty and environment performances vary among provinces. Thus, it is expected that individual provincial performance on poverty-environment nexus in a point of time and over time are also vary.

1.5. Limitation of the study

Given all the complexity of the poverty environment nexus, it is not possible for this study to accomplish all aspect related to the nexus that are earlier mentioned. This paper has tried to seek the pattern of the nexus in national and regional level and adequate data for longer time period is needed to get more robust results. Unluckily, these data were not available at the time of research.

1.6. Organization of the paper

This paper is constructed into several buildings of chapters. Review from existing literatures is given in the second chapter after introduction. The third chapter highlights the overview of the poverty and environment condition in Indonesia. The data and methodology is then explained in chapter four. The results and discussion are presented in chapter five. Finally, chapter six presents the summary and conclusion.

Chapter 2
Concept of poverty environment nexus

2.1. Introduction

This section narrates briefly on working definition of poverty and environment nexus from relevant literatures. It also describes empirical evidences from some studies. Based on these previous studies, this part will be concluded by presenting an analytical approach for elucidating the poverty environment nexus in Indonesia context.

2.2. Poverty concept

Poverty concept has been evolved over years. It also has been described as a dynamic concept (Misturelli and Heffernan 2010). To start with one of the classic papers, Hagenaars and De Vos (1988:212) define three general definitions of poverty using household survey. The first way of conceiving poverty is in its objective or absolute term. Define it in an *absolute term*, "poverty is having less than an objectively defined, absolute minimum" This term is not only using basic needs approach such as food, clothing and housing but also food/income ratio, fixed cost/income ratio, total expenditure/income ratio (ibid:213). Next, poverty could be a *relative term* when comparing the haves with the have-nots in society with respect to income and commodities (ibid:215). However, this definitions using commodities based approach is rather weak because those who lack of certain commodities commonly utilized in society may not considered as poor due to based on solely on individual options. Lastly, poverty can also be defined in term of *self-definition* that is "the feeling you do not have enough to get along" (ibid:215). This subjective measurement defined using subjective minimum income and consumption definition.

In another conceptualization of poverty, Hallerod (1995:113-115) categorizes the definition of poverty to indirect and direct concepts where *indirectly* is in term of access to economic resources while *directly* is in term of standard of living as an outcome. On the one hand, the indirect definition of poverty only uses money income as measurement of economic resources without considering any other kind of resources such as income in kind and informal resources. In direct definition of poverty, on the other hand, people's well-being are measured in the relation of other kind resources in the society.

Due to the latest journal by Chandrasekhar (2010), the definition of poverty has been broadened. He argues that the definition of poverty in India should consider the condition of housing as a component of measurement. The argument of this poverty definition based on the fact that those who consider having livelihood above poverty line are living in slum areas with poor housing such as dirty floor, bad ventilation, flooding experience and without access to drinking water in the building.

The definition of poverty this paper uses is Comim et al.'s which reads: "Without entering into controversies about what is the best of assessing poverty, it is possible to acknowledge that all poverty concepts (and their respective measures) have something in common: poverty is about a minimum condition below which no human being should live. It is about a threshold that defines a basic condition for humanity (Comim et al. 2008:6). This paper follows this definition since it is broadly accepted to measure poverty for decades.

2.3. Environment concept and its link to poverty

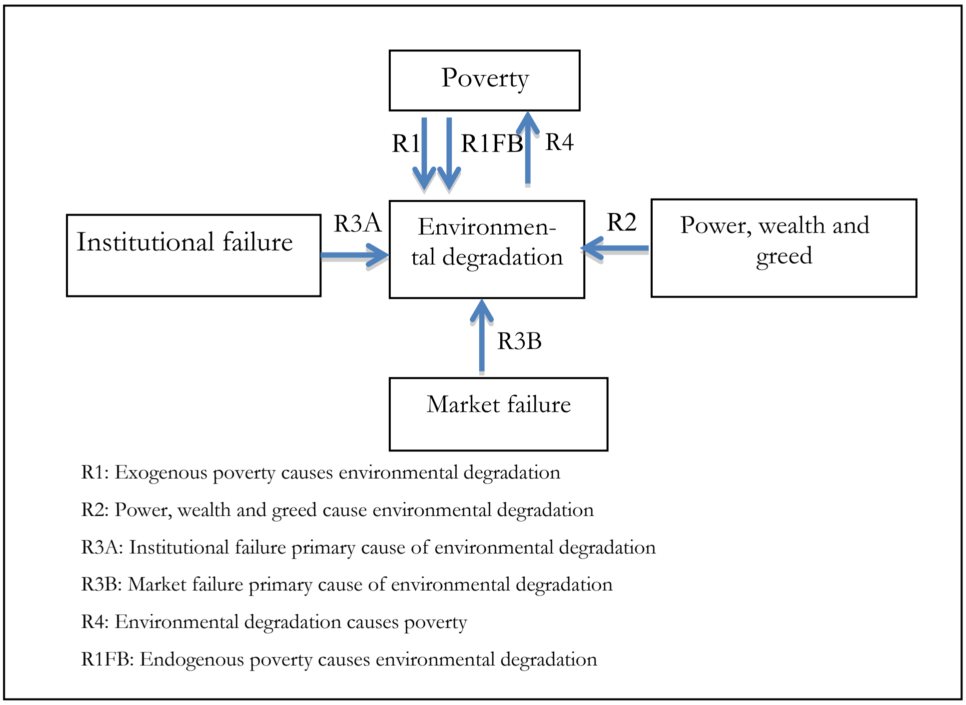
Refer to the definition given by DFID et al (2002), environment is "the living (biodiversity) and non-living components of the natural world and to the interactions between them, that together support life on earth". The environment provides goods (natural resources) and services (ecosystem function). Millenium Ecosystem assessment (2005) uses "ecosystem" term to refer the environment. MEA categorizes ecosystem services that is "the benefits people obtain from ecosystem" based on the characteristics of the goods and services. Some ecosystem services are characterized into supporting, provisioning, regulating, or cultural ecosystem services. MEA also deals with integral concept of ecosystem services and human well being (Appendix A).

Understanding the connection between poverty and environment is particularly challenging due to broad concept of poverty and environment (Nunan et al. 2002). The frameworks often see the generalization of the nexus as a two-way relationship between poverty and environment. Be indebted to definition from UNDP (2010:15), poverty and environment nexus is " a set of mutually reinforcing links between poverty and environmental damage". On one side, sound environment condition is prerequisite for alleviating poverty. Poverty can force people, on the other side, to degrade the environment in which their livelihoods mostly depend on it. This situation represents a "downward spiral" (Scherr 2000) and " poverty trap thesis" (Prakash 1997).

However, Duraiappah (1998) illustrates the linkage of poverty and environment nexus is not simple rather it constitutes many other factors such as institutional and market failure. In his paper, he defines endogenous poverty as poverty caused by environmental degradation and exogenous poverty as poverty caused by other external factors. Thus, the web of relationship between poverty and environment is developed as illustrated in figure 2.1. The direction of R1, R1FB and R4 reflects the classic view of the causality of poverty and environment. External factors such as power, wealth and greed as well as institutional failure and market failure also can affect environmental degradation through R2 and R3A links. The words of Pellegrini and Dasgupta (2011:13), moreover, provides important message of the link between environment and people through tenure security as institutional component. As cited, "in the open access case the most valuable forest products will be rapidly depleted and forest degradation and/or deforestation follow".

Congruent with Duraiappah, Ekbom and Bojo (1999) have specified several hypotheses of poverty-environment link. Firstly, due attention to vulnerability to lose of physical resources, to environmental stress and to inequality, the poor are wounded from environmental degradation. Second, since the rural poor are often exploit fragile areas such as steeply sloped hillsides or derive resource from protected areas, therefore, it is stated that the poor people are agents of environmental degradation. Indeed, high population growth will foster the poor to exploit new marginal lands. However, in a global scope, it is vivid that growing economies have more pressure to the environment rather than poor economies do. Fourth, weak property rights are the driving factor for the poor force environmental damage. Lastly, population exogenously influences poverty and environmental degradation. The rational is densely populated areas normally have high pressure to the environment and this will lead to aggravate poverty.

In a different view with Duraiappah and Ekbom and Bojo, Prakash (1997:24) reconsidering aspect of poverty into the environment by stating, "down ward spiral is unduly simplistic; that the relationship between poverty and environment is mediated by institutional, socio-economic and cultural factors". Further, "the proper relationship between poverty and environmental degradation should largely be seen as one of coincidence rather than of the spiralling chain of cause and effect implied by the poverty trap thesis".



Source: Duraiappah 1998, Hughes et al. 2009

Figure 1 Poverty environment relationship

The complex perspective of the correlation between poverty and environment thus calls the need to generate general poverty-environment indicators since both issue have been looked separately (Nunan et al. 2002). In their study, several environmental issues were identified relevant to the poor such as environment and health (including malaria, diarrhoea and respiratory infection from indoor air pollution), forest cover, water quantity and quality, soil degradation, fisheries and natural disaster. Poverty-environment indicators also reflect institutions such as tenure and property rights and access to drinking water and sanitation.

DFID et al. (2002) and De Coninck (2009) also develop several indicators to understand poverty-environment nexus in rural and urban setting. They examine how environmental changes affect the poor in three dimensions: livelihood, health and vulnerability and also concern on the relationship between growth and environment and their effect to the poor. Their discussion addresses the link that the poor are rely on natural resources as an income source and the poor population live in ecologically vulnerable areas such as dry lands and steeply sloped areas. Another main environmental problems are lack of access to natural resource due to natural resource degradation. Women suffer more in time and physical burden due to the long travelled time and distance to collect wood fuel and clean water, which in turn will lower their performance in income generating activities. The poor particularly women and children also facing high risk health problem such as respiratory infection, diarrhoea and malaria due to high exposure of indoor air pollution, lack of safe water and sanitation and exposure of disease vectors. Furthermore, the poor is also showing high insecurity due to environmental shocks such as floods, droughts, and others natural disaster.

In Indonesia context, however, little is known about the poverty and environment nexus in this country. Preliminary descriptive studies have been conducted at identifying the link between forest and poverty only in one point of time, 2003. Using correlation method on provincial unit of analysis, the result suggests that at the national level there is moderate correlation between percentage of rural poverty and percentage forest cover (CESS-ODI 2005).

2.4. Human development concept and its link to poverty and environment nexus

Lufumpa (2005) have studied the nexus of poverty and environment in Africa and by using spatial mapping found that there is correlation between child mortality and land degradation in West Africa. As cited from Zuehlke, E. (2011) that gives supporting arguments:

> "Environmental risks to the poorest populations vary by human development level. The poor in low-HDI countries tend to face household environmental deprivations such as indoor air pollution and inadequate sanitation and drinking water. Those in rising economies tend to face environmental risks with localized effects such as urban air pollution. In high-HDI countries, on the other hand, environmental risks such as greenhouse gas emissions tend to have global effects, and rise with the HDI" (Zuehlke. 2011).

Furthermore,

> "These environmental factors lead to wide-ranging risks to human health and education. For example, indoor air pollution kills 11 times more people in low-HDI countries than other countries; and environmental-related diseases like acute respiratory infections and diarrhoea resulting from dirty water and sanitation kill 3 million children under 5 each year. The use of modern stoves and indoor plumbing could save time from collecting firewood and water and allow more time for children to attend school"(ibid).

These two arguments have shown the relationship between HDI and environmental vulnerability. Moreover, as cited from Kanjee and Dobie (2003) that have identified the link of human development indicators to the environment (table 2.1), it is well articulated that human development and environment are integrated. Furthermore, the effect of the environment also can be seen in term of livelihoods, health and vulnerability. In term of livelihood, the environment provides water and energy that is essential for livelihood, in turn, for development. In term of health and vulnerability, least developed people are most likely exposed to the effect of environment-related disease, pollution and natural disasters (ibid.).

Table 1 Impact environment on HDI

<table>
<tr><th>Human development indicators</th><th>Link to the environment</th></tr>
<tr><td>Life expectancy at birth</td><td>Lack of adequate access to natural resources for food, clean air and safe water as well as vulnerability to natural disasters affects the health and life span of an individual.</td></tr>
<tr><td>Adult literacy rate</td><td rowspan="2">Scarcity of natural resources in rural areas often means that family members (particularly females) are required to help in time-consuming household chores (e.g. collecting fuel wood or water) rather than educational activities or school.</td></tr>
<tr><td>Enrolment ratio</td></tr>
<tr><td>GDP per capita</td><td>Lack of healthy natural resources (e.g. fertile land) means less income from agricultural activities. Natural disasters also have a major impact on GDP.</td></tr>
</table>

Source: (Kanjee and Dobie 2003)

2.5. Empirical evidences

Dasgupta et al. (2003, 2005) investigate the poverty-environment nexus at provincial and district level in Cambodia, Lao PDR and Vietnam. Using spatial analysis and regression they focus on absolute poverty measurement and five critical environmental problems that are deforestation, fragile land, indoor air pollution, contaminated water, and outdoors air pollution. The elements of poverty-environment nexus are developed by some prepositions that are going to be tested. First, to test a poverty-environment nexus in deforestation context, they assess correlation between poverty and deforestation using map analysis, scatter plot and regression. Evidence from Cambodia using comparison between map of deforestation rate and map of poverty population in district level shows that the nexus between poverty and deforestation is present due to areas with high poverty incidence is also deforested area. This result is also supported by a rank correlation showing a weakly relationship of 0.15. Regression analysis is also employed to grasp the effect by using log (forest cover 1997/forest cover 1993) as dependent variable and log (poor/forest cover 93) and log (population/forest cover 93) as independent variables. The result suggests that population, as a whole, is a major cause of deforestation.

Second, they test the nexus of poverty and environment in context of fragile land. The nexus exists when poverty population is condensed in steeply sloped areas. The insight belies on the potential for erosion and soil degradation in highland areas caused by the poor. However, the overlapping map of percentage of land those are steeply sloped and map of total poverty population shows that few poverty populations live in steeply sloped areas. Scatter plot analysis also presents the negative relationship (-0.29). Third, the nexus between poverty and environment in context of indoor air pollution also has been tested. The scatter plot shows strong correlation between poverty population and population using fuel wood (0.70). Regression result also suggests significant relationship between poverty and wood fuel use.

Further, correlation between poverty and lack of access to clean water also can be seen as the nexus between poverty and environment. Regression and map analysis success to show that poor household strongly associated with less access to safe water than higher income households. Outcome indicator of less access to safe water used in their paper is child mortality, which also shows spatial correlation between distribution of childhood death and poverty population. Finally, the nexus of poverty and environment in term of outdoor air pollution can be seen using map of distribution of pollutant and shows that periphery has higher polluted area. There is also association between poverty populations and numbers of deaths suffer from outdoor air pollution shows correlation between them (0.14).

In line with Dasgupta et al., Shyamsudar (2002) works on identifying the environmental indicators that determine poverty through two channels: environmental indicators that determine health of the poor and natural resource condition that determine livelihood of the poor. For the first channel, respiratory infection and diarrhea are the biggest impact of lack of proper indoor air quality and lack of access to clean water. Also, vector disease such as malaria is caused by poor water quality. Furthermore, environment detrimental also affect poor livelihood. Using time spent to or distance travelled to collect water or fuel wood is the indicator in which environment degradation burden poor people. Besides, Twesigye (2007) in his report also cluster the key poverty-environment indicators for Rwanda into three categories. There are poverty-livelihood, poverty-health and poverty-vulnerability. For poverty-livelihood indicators, it is including percentage of household using fuel wood as a source of energy and access to water while for poverty-health indicators include prevalence of diarrhea and malaria and access to adequate sanitation facilities. Finally, poverty-vulnerability indicators are percentage of population who are exposed to the risk of floods, landslides or drought and incidence of illness or death due to floods, landslides or drought.

Furthermore, Aggrey et al (2010) by using spatial and regression analysis also examine poverty-environment nexus in Uganda. They use headcount poverty index as poverty variable and deforestation, water pollution, indoor air pollution and wetland conversion as environmental degradation variables. They found that deforestation and wetland degradation are positively linked with poverty compared to access to clean water, access to toilets and access to electricity. It is hold the hypothesis of the poor causes environmental degradation and vice versa. Thus, it concludes that the poverty environment nexus occurs in Uganda.

Other scholars have also gone through the work on the downward spiral of poverty-environment nexus. Bhattacharya and Innes (2006) examine the bi-directional relationship between rural poverty and environmental change using district level in India. Using linear regressions, they address two hypotheses that are environmental degradation is led by higher rural poverty and the severity of poverty will increase due to environmental damage. Due to data in forest cover are not available, they measure environmental changes in term of vegetation using the Normalized Difference Vegetation Index (NDVI). Poverty indicator is proxied by rural and urban consumption expenditure to measure poverty gap index and squared poverty gap. Beyond that, several exogenous explanatory variables are used to explain changes in environmental performance. They are climatic factors (initial vegetation and average rainfall), demographic factors (rural population growth rate and rural population density), rural income distribution (rural per capita consumption expenditure, initial rural poverty, rural Gini-coefficient), land use pattern (proportion of area under agriculture) and social indicators (rural literacy rate, rural sex ratio and rural female work force participation rate).

In order to answer their hypotheses, rural poverty change used in the model is treated as endogenous variable. Hence, instrument variable such as rural infant rate and average rural household size are employed into the model. Similarly, environmental changes are also treated as endogenous variable and rainfall is employed as an instrument variable. Statistical results from two-step Generalized Method of Moment (GMM) suggest that rural poverty negatively affect environmental performance and vegetation degradation spurs rural poverty. Besides, social factors also play important role in changing in poverty and environment.

Moreover, Sunderlin et al (2007) use scatter diagrams and correlation tests, mapping and spatial association test argue that human well-being and forest cover are a joint problem; therefore, change in living standard will affect changing in forest cover or vice versa. However, their study did not aim to seek the causality between poverty and forest; rather, they only try to find out the spatial pattern of association. The Pearson test resulted in the correlation between poverty rate and forest cover are weak at the national level. Scatter plot also was used in their study and showed that there is no pattern between poverty and environment. Further, bivariate spatial association test was employed to look forward the association between forest cover to poverty rate and forest cover to poverty density. The result suggests that on average, there is strong coincidence between highly forest cover areas are correlated to high poverty rate. However, there is weak association between high forest cover and number of poor people living in this area.

2.6. Nexus measurement-the framework

This paper addresses three aims: (1) to analyse the correlation between rural poverty and several indicators of environment at the provincial level; (2) to examine the causality pattern between forest coverage and rural poverty rate; and (3) to find out individual and inter-temporal poverty environment indices across provinces. In order to analyse the state of poverty and environment linkage this paper employs some statistical tools to find out the relationship between poverty and environment.

2.6.1. Assessing correlation

The link between poverty and environment could be examined by correlation testing to find out the dependency of these indicators. In order to reveal the correlation between poverty and environment, this paper uses three channels to explain the poverty-environment nexus: livelihood, health, and vulnerability.

- Poverty and livelihood

Environmental degradation causes loss of biodiversity as well as soil erosion that the poor rely their livelihood on it. Thus, to test whether a poverty environment nexus exists, this assess using graphical scatter plot to find out the spatial correlation. Thus, this paper tests whether poverty rate and poverty density correlates with the area under forest cover.

- Poverty and health

This study selected one of environmental issue that relates with poverty that is indoor air pollution. Indoor air pollution (IAP) is caused by solid fuel usage as cooking energy. As suggested by many studies that fuel wood usage is correlated with the prevalence of respiratory infection, thus this paper tests whether there is significant association between low-level standard of living, usage of fuel wood and and the prevalence of respiratory infection.

- Poverty and vulnerability

Environmental degradation drives environmental risks such as flood and drought. Hence, this paper also tests whether the poor is also vulnerable to expose these risks.

2.6.2. Assessing Granger causality

Literatures acknowledge that there is bi-directional causation between poverty and environment. While some other literatures play a contention on it. Hence, this study puts those hypotheses into the Granger framework by estimating variable of poverty and variable of environment in lag value. Refer the study conducted by Hood et al (2008:328), there are three possible causalities between two variables:

1. Causality exists between x and y in *all* cross-sections identically.
2. No causal relationship exists between x and y in *any* cross-section.
3. In some subset of n cross-sections, (i) at least one cross-section *i* hold causal relationship; (ii) at least one cross-section *i* hold no causal relationship.

Further, Hood et al formulate the Hurlin and Venet's formalization of the TSCS Granger framework to cope with the various possibilities of causality scenarios above, implies that:

$$E(y_{i,t} \mid y_{i,t-1}, y_{i,t-2}, \ldots y_{i,0}, \alpha_i) = E(y_{i,t} \mid y_{i,t-1}, y_{i,t-2}, \ldots y_{i,0}, x_{i,t-1}, x_{i,t-2}, \ldots x_{i,0}, \alpha_i) \quad \ldots\ldots(1)$$

for every cross-sectional unit in the panel. According to the equation, expected value of y given information of y in the past and information of x in the past is equal with expected value of y given only the information of y in the past. Thus this model gives the null hypotheses to cope with the first causality scenarios above. By rejecting the null hypotheses means x does not cause y for each cross-section *i*. Alternatively,

$$E(y_{i,t} \mid y_{i,t-1}, y_{i,t-2}, \ldots y_{i,0}, \alpha_i) \neq E(y_{i,t} \mid y_{i,t-1}, y_{i,t-2}, \ldots y_{i,0}, x_{i,t-1}, x_{i,t-2}, \ldots x_{i,0}, \alpha_i) \; \forall_i \in (1,2,\ldots N) \quad \ldots\ldots(2)$$

implies that expected value of information of y in the past and expected value of x in the past is considerable to determine the expected value of y at present. Thus, rejecting the null hypotheses of model (2) indicates that there is causal relationship all cross-sections.

The third scenario does not require causality identically presenting in every cross-section. Heterogeneous causality presents if the model (2) allows at least one cross-section *i* to have causality relationship or similarly, if at least one cross-section *i* indicates no causality relationship by examining model (1).

2.6.3. Assessing poverty environment link-across provinces and inter-temporal indices framework

This paper examines how poverty linked with environment through indices computations that are poverty index, environment index, and poverty-environment index. These indices represent provincial vulnerability in a particular time. However, in order to obtain marginal progresses over time whether or not these indices have improved, hence, temporal shift is computed by differencing them in two periods.

2.7. Conclusion

Literature review highlighted the challenges of understanding the state of poverty-environment nexus. In general, there are three dimensions of the nexus between poverty and environment. Environment might have impact on poverty through their livelihood and also change in environment might influence the poor through their health. Further, the nexus might come from the exposure of risky environment to the poor. In order to seek the nature of the nexus, causality assessment and correlation assessment were decided as framework in this study.

Chapter 3
The state of poverty, forest and forestry: Indonesia context

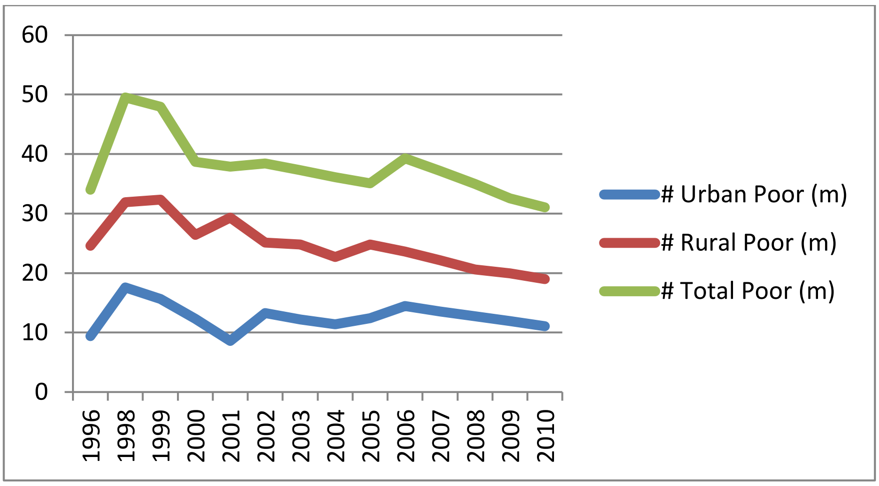
3.1. Introduction

Poverty has been the main problem in development process in Indonesia. Compounded with environmental problem, it is heading this country to face a serious development challenges. This chapter narrates the nature of poverty and environmental condition in Indonesian context.

3.2. Poverty highlight

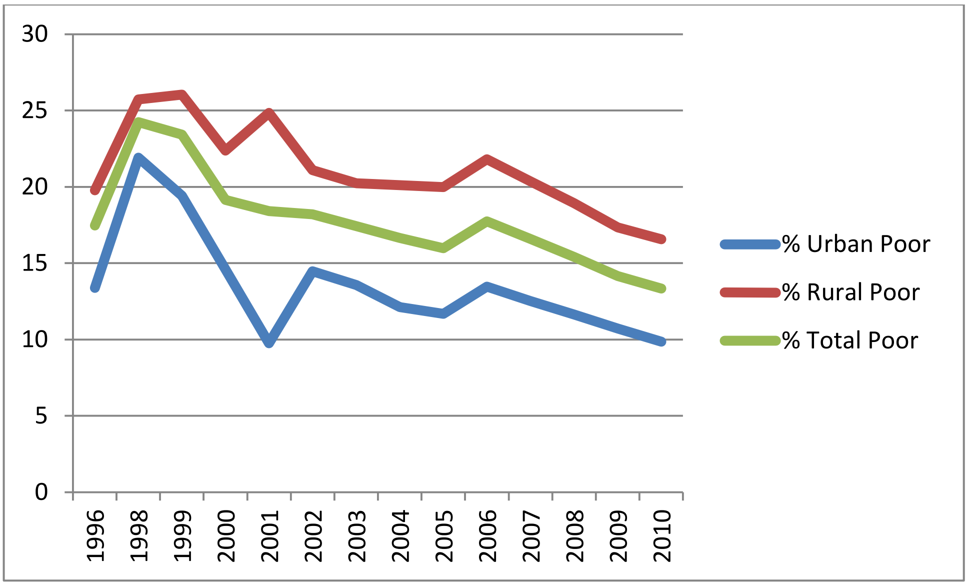
Indonesia has been experiencing declining trend in absolute number of poor people. Since 1996 to 2010, the number of poor people declined from 34 million to 31 million. However, some fluctuation presented in 2006 while this country had an economic shock due to financial crisis. Among the total 30 million poor people, around two third reside in rural areas (figure 2). In a relative value, rural poor has contributed in 16.56 per cent to the total population while urban poor is also around half of it (Figure 3).

Besides, as like many other developing countries, Indonesia also has been experiencing income inequality. This inequality problem is also the main impediment for development process, however, the data for the last five years shows that Gini coefficient has increased from 0.33 to 0.41 in an aggregate value. In rural context, the figure moved from 0.27 in 2005 to 0.34 in 2011. Similarly, in urban areas also has an increasing trend from 0.32 in 2005 to 0.42 in 2011.



Source: Statistics Indonesia

Figure 2 Number of poor people in Indonesia



Source: Statistics Indonesia

Figure 3 Percentage of poor people in Indonesia

The burden of poverty is not equally distributed among regions in Indonesia. Table 2 illustrates the number of poor people in different islands in Indonesia. Java Island has the highest absolute number of poor that is about 7 million people compared to other regions/islands. However, the proportion of the total number of poor people to total population is higher in Maluku and Papua compared to others regions.

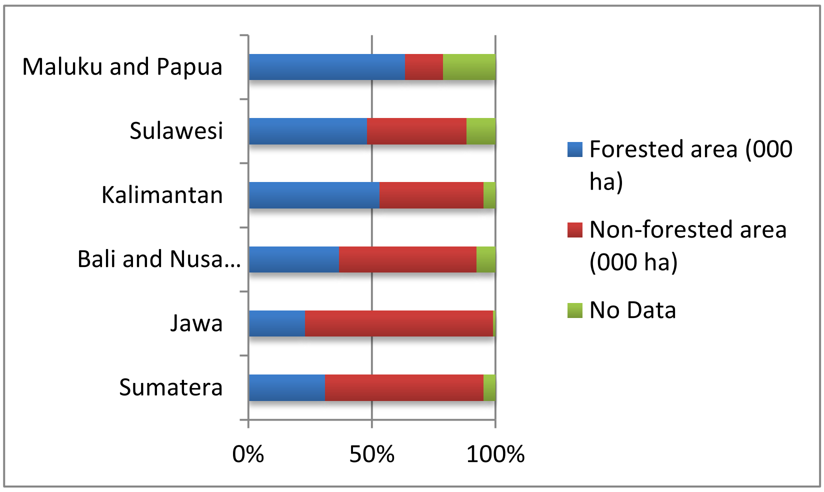
Table 2 Distribution of poor among island, March 2013

Island	Number of Poor People (thousand)			Percentage of Poor People		
	Urban	Rural	Total	Urban	Rural	Total
1	2	3	4	5	6	7
Sumatera	2008.33	4111.09	6119.42	9.64	12.72	11.51
Jawa	6996.12	8365.75	15361.87	8.48	14.40	10.92
Bali and Nusa Tenggara	601.31	13885.60	1986.91	11.17	16.67	14.51
Kalimantan	247.45	678.21	2025.78	4.01	8.12	6.37
Sulawesi	348.27	1677.51	2025.78	5.74	13.99	11.22
Maluku and Papua	124.05	1522.87	1646.92	6.14	31.40	23.97

Source: (Statistics Indonesia 2013)

3.3. Forest and forestry in Indonesia

Forest area is particular forested area that is designed formally by the Government to be a permanent forest. According to the Act on Forestry No.41/1999, forest area has three categories that are conservation forest, production forest and protected forest. Forest area differs from land/vegetation cover that surface condition of an area (Ministry of Forestry Republic of Indonesia 2008). Data on land cover area includes forested land, non-forested land and some parts of area that has data deficiency. Forested land includes primary dry land forest, secondary dry land forest, primary swamp forest, secondary swamp forest, primary mangrove forest, secondary mangrove forest and plantation forest. Non-forested land includes bush/shrub, swamp shrub. Shrub-mixed dry land farm, estate crop plantation, settlement area, dry land agriculture, swamp, savanna, rice field, barren land, fishpond, transmigration area, mining area, airport. Data deficiency on forest cover also presents due to cloud cover in the interpretation of the satellite imagery and due to an absence of the data. Figure 4 illustrates land cover by regions. Maluku and Papua constitutes as an island that has the highest forested area compared to Java.

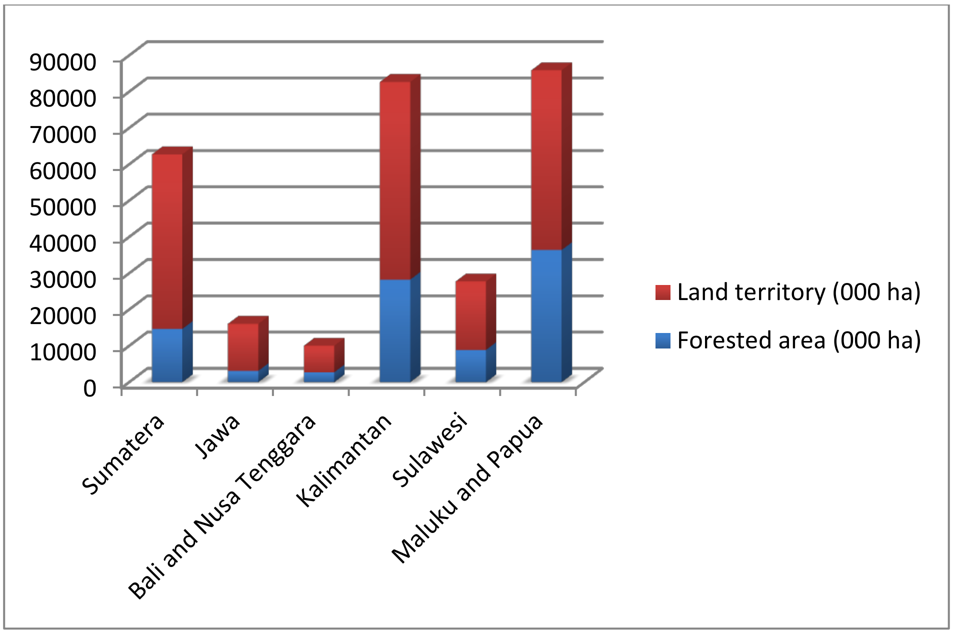


Source: (Ministry of Forestry Republic of Indonesia 2008)

Figure 4 Land cover statuses by major islands (2006)

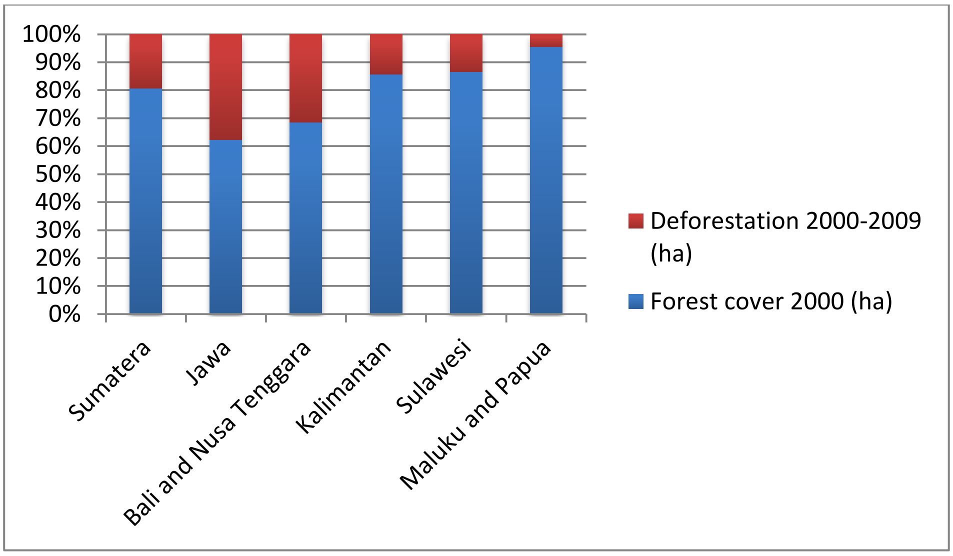
In 2006, out of the total 1,910,931.32 km^2land territory of Indonesia, forested area constituted 93,924.33 thousand hectares or around 50% of the land territory. However, the potential forested areas are not distributed proportionately among regions (Figure 5). Java Island has the lowest forested area that is only 24% out of the land territory and it is followed by Sumatera region and Bali and Nusa Tenggara region with 30% and 36%, respectively. Maluku and Papua region, again, comprises the land with the highest proportion of forested areas that cover more than 73% of the region; that is followed by Kalimantan and Sulawesi, 52% and 47% respectively

Forest conversion and degradation is inevitable during the development process in this country. The data from Forest Watch Indonesia (2011) shows that deforestation occurs in an expense of human activities. Owing to the definition of deforestation from Ministry of Forestry Republic of Indonesia, (2008), " Deforestation is defined as land cover changes from forested land to non-forested land including for estate crops, settlement, industrial area, etc.". Figure 5 illustrates that the highest deforested area is in Java Island. On contrary, Maluku and Papua represent the lowest deforestation rate.



Source: (Statistics Indonesia 2011) and (Ministry of Forestry Republic of Indonesia 2008)

Figure 5 Ratios between forest cover and land territory 2006



Source: Computed from data (Forest Watch Indonesia 2011)

Figure 6 Deforestation among regions

3.4. Conclusion

This chapter has shown the nature of poverty, forest and forestry in Indonesia. It has overviewed both national and regional trends in terms of distribution of the poor, forest coverage and deforestation. This background information is intended to set the context to guide development of methods and analysis of findings in the following chapters.

Chapter 4
Data and methodology

4.1. Introduction

This chapter presents the methodology and data analytical tools used in the study. It also describes the data and analytical techniques employed to examine the nexus of poverty and environment in the study area.

4.2. Data descriptions

The study mainly employed quantitative data to examine the relations of poverty and environment indicators. Numbers of indicators used in this study are rural poverty rate, rural poverty density, forest coverage, number of pneumonia cases, and number of cropland affected by flood and drought. The data was obtained from Statistics Indonesia and is collected from the National Survey for Social Economics of Household. This data provides us information about social economics of household. Further, data for environmental indicators were obtained from Statistics of Forestry Planning, Ministry of Forestry. It provides information about deforestation and forest cover. The data set used in this paper has a wide range of important variables. For example percentage of rural poverty recorded in the data ranges from 0 to about 70 percent. Similarly, forest coverage also ranges from around 4 percent to 89 percent. Further, province that has zero rural poverty is DKI Jakarta; hence this province was omitted from the analysis.

4.2.1. Forest cover

Forest cover is used to measure the environmental quality in the study. The data of forest cover is gained from the interpretation of data satellite imagery 7 ETM+ that is available for 1999/2000, 2002/2003, and 2005/2006 and 2009/2010 and then these data from satellite image were interpreted in each year from 2001 to 2010 provided us annual data of forest cover. Area under forest cover includes primary dry land forest, secondary dry land forest, primary swamp forest, secondary swamp forest, primary mangrove forest, secondary mangrove forest and plantation forest. The availability of land use data is divided into three. Those are forested land, non-forested land and no data (due to cloud that makes difficult to interpret the image).

4.2.2. Head count poverty index

Poverty indicators used in this paper is number of poor people in rural areas that are called as rural poverty and also headcount poverty index. Headcount index P_0 is "the proportion of the population that is poor, people earning or spending below the poverty line (Haughton and Khandker 2009). The formula is:

$$P_0 = \frac{N_p}{N}$$

where N_p is the number of poor and N is the total number of population.

4.2.3. Household use of solid fuel

The data of household using fuel-wood as energy source was obtained from Statistics Indonesia. That is an annual data of the percentage of household that use solid fuel based on provincial basis.

4.2.4. Pneumonia prevalence

Pneumonia indicator used in this paper is the number of pneumonia cases among children under five years old. This paper employed panel data set from 32 provinces over 2007-10.

4.2.5. Paddy crop affected by flood and drought

Paddy crop affected by flood and drought is measured in number of hectares. This data ranged only for short time period that is from 1999 to 2002 consider to the availability of the statistical data.

4.3. Methodology

To test nature, direction and strength of the relationship between poverty and environment, several tests need to be employed. These are Pearson Correlation test, causality testing and cross-regionally and inter-temporally testing for poverty-environment performance.

4.3.1. Pearson correlation

Pearson correlation is useful to seek the direction and the strength of the association between two quantitative variables (Agresti and Agresti 1970). Given the equation $\hat{y} = a + bX$, the Pearson correlation *r* is $r = \left(\frac{s_x}{s_y}\right) b$,

where $s_x = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$ and $s_y = \sqrt{\frac{\sum(Y-\bar{Y})^2}{n-1}}$

To test the null hypothesis $H_0: \rho = 0$ where ρ is the population of r from $E(Y) = \alpha + \beta X$ is by computing the t-stat $t = \frac{r}{\sqrt{(1-r^2)/(n-2)}}$ with $df = n - 2$

4.3.2. Causality testing in panel data

This study employs several tests for assessing causality in panel data following approaches developed by Hurlin and Venet (2001) that is also obeyed by several studies for time series cross-sections (TSCS) framework by Erdil and Yetkiner (2004) and Hood et al (2008). The causality test is deliberated to test homogenous non-causality and homogenous causality for all cross-sections in the sample. Later, the heterogeneous non-causality test was also composed. Figure 7 gives an idea of the steps of causality testing in panel data set. Following Erdil and Yetkiner (2004) the panel data model below is estimated for causality testing.

$$y_{i,t} = \sum_{k=1}^{p} \beta_k y_{i,t-k} + \sum_{k=o}^{p} \theta_k x_{i,t-k} + \mu_{i,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

- Homogenous non-causality test (HNC)

Homogenous non-causality test is designed towards testing whether or not the slope θ_k's of $x_{i,t-k}$ are constrained to zero for all cross-sections. In other words, this test is directed towards whether or not *x* does not cause *y* for every cross-section. The following models under null hypothesis is:

$$H_0: \theta_k = 0 \forall i \in [1,N], \forall k \in [0,p] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$H_1: \theta_k \neq 0 \exists (i,k)$$

In order to assess the non-causality for all cross-sections, we need to compute the F-stat based on the sum squared of error from restricted and unrestricted model. The restricted model constitutes the expected current value of *y* is only determined by the expected lagged value of variable *y* and its fixed effect (α_i). However, for unrestricted model, it includes all lagged value of the variable *y* itself and lagged value of variable *x*, and its fixed effect (α_i). To test whether the causality present or not, the F-test formula used is as follows:

$$F_{HNC} = \frac{(RSS_R - RSS_{UR})/(Np)}{RSS_{UR} / [NT - N(1+p) - p]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

where N is number of cross-sections, p is the number of lags and T is the number of time periods. The result of F_{HNC} thus needs to be compared with the F-distribution with *Np, NT-N(1+p)-p* degree of freedom. If the null hypotheses is rejected thus implies that at least at one of cross-section *i, x Granger causes y*. Hence, further step needs to be conducted in order to test whether the causality presents for all cross sections that is called homogenous causality test.

- Homogenous causality test (HC)

Since rejection of the null hypothesis of homogenous non-causality indicates that there is possibility for at least one cross-section to have causal relationship. Thus, in a sequential way, homogenous causality test is determined to test whether or not the causality exists for all cross section. The hypotheses under this case area:

$$H_0: \theta_k^i = \theta_k^j \ \forall i,j \in [1,N], \forall k \in [0,p] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$H_1: \theta_k^i \neq \theta_k^j \ \exists (i,j,k)$$

Fails to reject the null hypothesis indicates that for all cross-section, the causality presents. Oppositely, if the null hypothesis is rejected, it implies that at least for one cross-section *i, x* does not Granger cause *y*.To test the F-statistic of this hypothesis, the unrestricted model is similar with the previous model for assessing F_{HNC}. However, the restricted model is quite different. The restricted model used in this hypothesis allows for each cross-section has the same slope coefficient.

In order to test the hypothesis, F-test formula is decided:

$$F_{HC}=\frac{(RSS_R'-RSS_{UR})/[P(N-1)]}{RSS_{UR}\ /\ [NT-N(1+p)-p]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

where $RSS_R'$is the sum of squared residuals from restricted model under the null hypothesis. If the F-test is rejected, it infers to the conclusion that at least in one of cross sections *i x* does not cause *y*. In other words, for all cross-sections *i* there is no homogenous causality presenting in this case. Then the causality of *x* over *y* goes only for individual cross-section. This conclusion leads to another step that is heterogeneous non-causality test.

- Heterogeneous non-causality test (HENC)

Rejection of the null hypothesis of homogenous causality test leads to two sequential tests. The first test is for examining which cross-sections that have causality *x* over *y*. In other words, the null hypothesis is tested for each cross-section; therefore, N individual test would be needed to identify which cross-section do have no causality. The first hypotheses tested are as follows:

$H_0: \theta_i^k = 0$ ∀i∈ [1,N], ∀k ∈ [0,p] ……………………………………………(6)

$H_1: \theta_i^k \neq 0$) ∀i∈ [1,N], ∀k ∈ [0,p]

The F-test is calculated using the formula:

$$F_{HENC1}=\frac{(RSS_R''-RSS_{UR})/p}{RSS_{UR}\ /\ [NT-N(1+2p)+p]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

whereRSS_R'' is restricted sum squared of residual for cross-section *i*. Fails to rejection of H_0 infers that there is an existence of set of group of cross-section that have no causality; therefore, this result will drive to the second testing that is heterogeneous non causality test as described in Hood et al(2008). This test is examined to find out the non-causality for each subset group of cross-section *j*. the following hypothesis testing is as follows:

$H_0: \theta_j^k = 0$ ∀i∈ [1,N], ∀k ∈ [0,p] ……………………………………………(8)

$H_1: \theta_j^k \neq 0$∀i∈ [1,N], ∀k ∈ [0,p]

The F-test statistic:

$$F_{HENC2}=\frac{(RSS_R'''-RSS_{UR})/n_{nc}p}{RSS_{UR}\ /\ [NT-N(1+p)-n_cp]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

where n_{nc} is the number of cross-sections under the null hypothesis while n_c is number of cross-section under the first hypothesis. Further, RSS_R''' is the restricted sum squared of residuals under the null hypothesis. Rejection of H_0 infers that *x* Granger cause *y* in the subset of cross-section *j*.

4.3.3. Cross-regional and inter-temporal poverty and environment vulnerability testing

The third method that is also employed in this study is poverty and environment vulnerability testing. This method examines the poverty vulnerability, environment vulnerability and joint poverty-environment vulnerability across provinces and over time ranged from 2002 to 2010. Measurement of poverty and environment indices in this study is following Agarwal (1997) who is also using UNDP method to link gender, poverty and environment in rural India.

The individual index is calculated using the following formula:

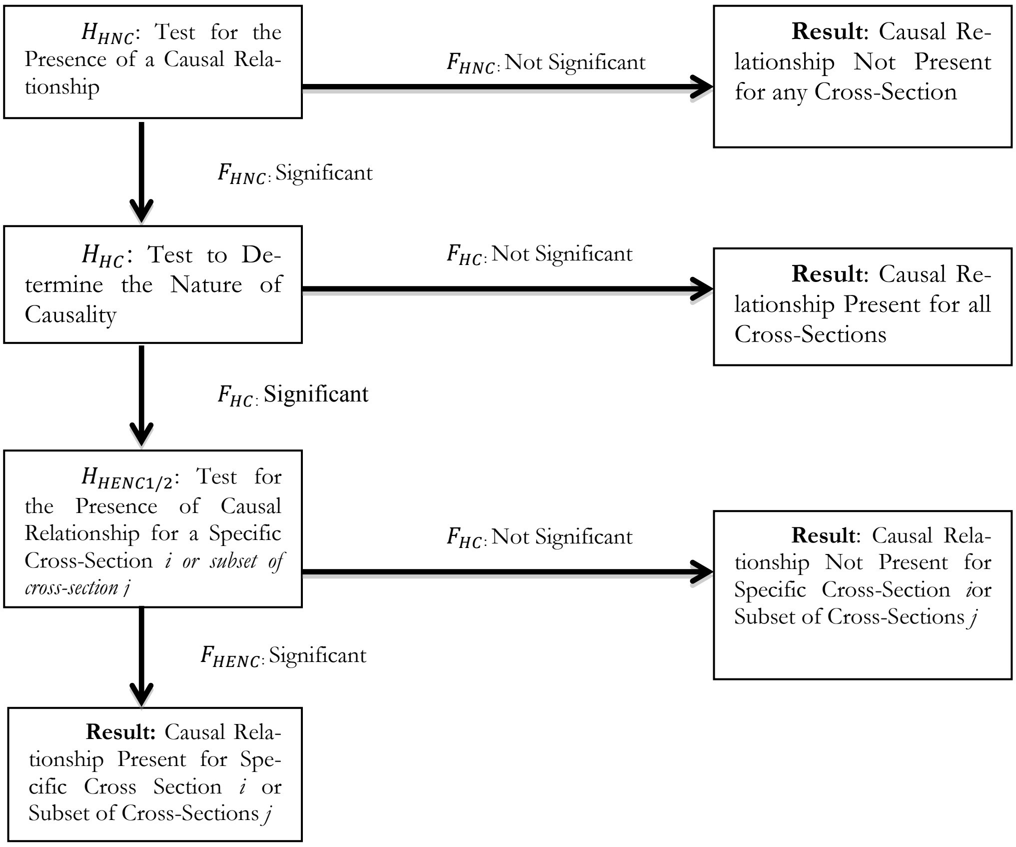
$$Z_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - min x_{ij}}$$

where x_{ij} denotes the actual value of an indicator in a province while max x_{ij} and min x_{ij} denotes the maximum and minimum value of an indicator in a point of time. For poverty index, its measurement was 1-Z_{ij}since the direction of the assumption is different with environment index. That is the higher the value of poverty index, the higher the vulnerability. It is different from the direction of environment index that is the higher the value of environment index, the lower the environment vulnerability. The poverty-environment index, furthermore, is a degree of joint vulnerability of poverty index and environment index by taking an average.

In order to measure a progress in changing poverty and environment vulnerability over time, it is following the same formulas but the maximum and minimum values are determined differently by choosing the maximum and minimum across provinces and times. Similarly, the inter-temporal poverty-environment index is a degree of joint poverty vulnerability and environment vulnerability over time.

4.4. Conclusion

The study used secondary quantitative data for environmental and poverty indicators. The dependent and explanatory variables were chosen based on literature review. The data was analysed through econometrics test using correlation test, causality testing, and index computation.



Source: Hood et al. 2008

Figure 7 Granger causality testing

Chapter 5
Result and discussion

5.1. Introduction

This part presents the findings from data analysis and discusses it in order to answer the research questions. First, this chapter shows the result of the correlation between poverty and environment variables in three different buildings. Next to this, the result of causality testing can be seen in the next sub heading that shows there is no bi-directional causality. Finally, across provinces differences in poverty and environment indices that show poverty-environment vulnerability can be seen in the last sub chapter.

5.2. Relationship between poverty and environment

As described in the previous chapter, the link between poverty and environment can be explored through several channels. Firstly, exploring the nexus of poverty and environment could not be apart from the link between livelihood and environmental resources since their income share from environment are relatively significant (Cavendish 2000:1996). As studied by Vedeld et al. (2007:872), meta-analysis from 17 countries shows that rural poor strongly depends on forest environmental income. Their income elasticity from forest income was 0.47. This large number of elasticity constitutes how important forest resource for the poor. Secondly, rural households are constraint for healthy energy sources for cooking. Their dependency on firewood has led to respiratory health problem. Ahmed (2005) provides an evidence of the close link between indoor air pollution and health in Guatemala. It is shown that biomass fuels as source of cooking and poor ventilation closely cause serious illness in children. Finally, the association between poverty and environment also can be linked in term of vulnerability due to environment detrimental such as flood and drought. A study conducted by Pauw and Thurlow (2009) in Malawi found that flood and drought have major implication for both rural and urban livelihood in term of food security in the country. Next, the relationship between poverty and environment in Indonesia context is given in the following results.

5.2.1. Poverty and livelihood in forest context

Descriptive Statistics

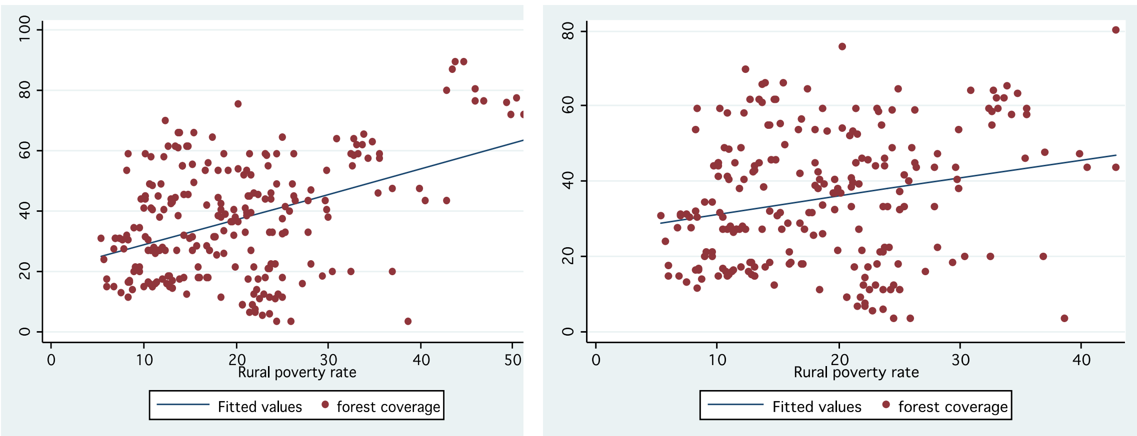
Table 3 Descriptive statistics of poverty and livelihood

Variable	Obs	Mean	SD	Min	Max
All provinces					
Forest coverage	301	37.59	18.907	3.766	89.565
Rural poverty rate	242	20.09	10.223	5.3	53.14
Rural poverty density (log)	275	5.615	0.4719	4.661	6.7542
Without Papua and West Papua					
Forest coverage	289	35.8	17.190	3.766	80.063
Rural poverty rate	230	18.6	8.2018	5.3	42.83
Rural poverty density (log)	261	5.60	0.4803	4.661	6.7542

Source: Author's computation

The characteristics of forest coverage and rural poverty rate and poverty density are given in table 3. The percentage of forested area per provinces in 2001 to 2010 ranges from 3.7 percent to 89.56 percent. Yogyakarta has the lowest forest coverage in 2001 while West Papua after its split-up from Papua has the biggest shared area of forested land. The share of the forest is more than 75 percent out of their land territory. Similarly, in term of rural poverty, West Papua and Papua also have the highest rank of poverty rate. However, in term of rural poverty density those provinces have the lowest numbers compared to other provinces.

Statistic result of the Pearson correlation between the coverage of forest in percentage and rural poverty rate is positively associated (r=0.4287, p-value=0.0000). Taking out Papua and West Papua results in lower correlation between forest coverage and rural poverty rate (r=0.2276, p-value=0.0005). Visual comparison is illustrated in figure 8.



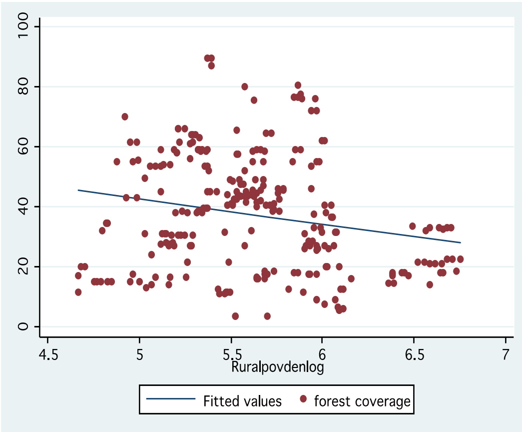
(a) (b)

Source: Author's computation

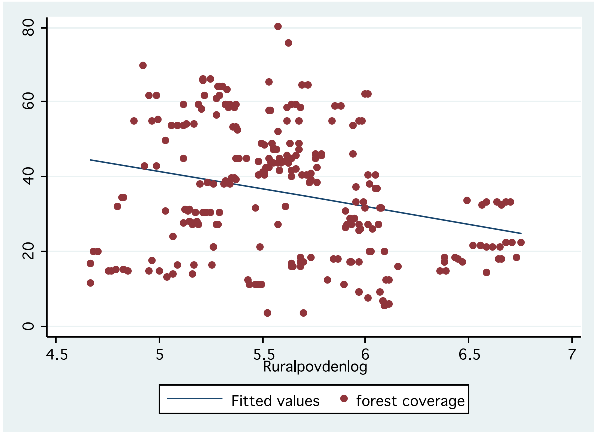
Figure 8 Scatter plot between forest coverage and rural poverty rate (a) all provinces (b) excluding Papua and West Papua

These scatter plot matrices indicate positive relationship and its association is positive and quite strong when includes all observations (Figure 8.a). However, when these Papua and West Papua are being excluded from observation thus high forest coverage is no longer closely associated with high rural poverty rate (Figure 8.b). This second result rather quiet weak since it generated another outlier. Hence, this paper suggests obeying for the first result, without dropping any provinces.

Furthermore, result from association between forest coverage and rural poverty density (Figure 9) shows they negatively have a weak correlation (r=-0.2086, p-value=0.0006). This result suggests that the area with high-forested land tend to have low number of poor people. After taking out the Papua and West Papua; however, this results in the same magnitude of correlation (r=-0.2612, p-value=0.000). Taking all the result in the relations above together, it can be concluded that areas with high poverty rate and low density are the areas with high share of forest.



(a)



(b)

Source: Author's computation

Figure 9 Scatterplot between forest coverage and rural poverty density (a) all provinces (b) excluding Papua and West Papua

5.2.2. Poverty and health in energy context

Descriptive Statistics

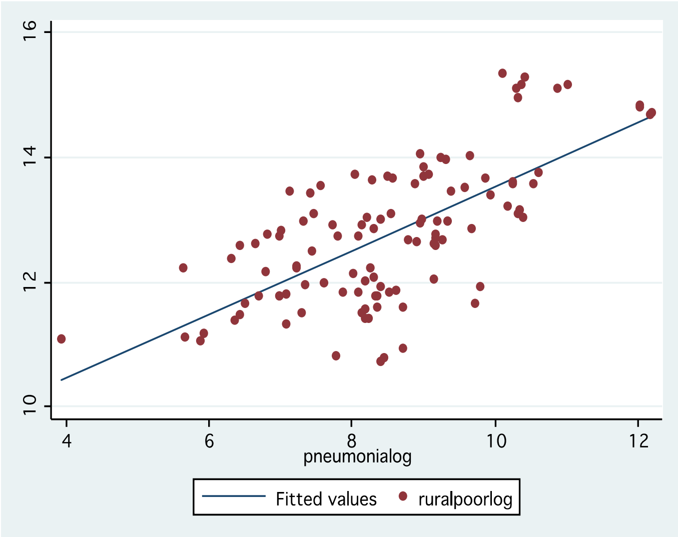
Table 4 Descriptive statistics of poverty and pneumonia

Variable	Obs.	Mean	SD	Min	Max
Rural poverty density (log)	128	12.785	1.084	10.734	15.337
Pneumonia (log)	110	8.515	1.495	3.931	12.189

Source: Author's computation

Indoor air pollution, respiratory disease and poverty are closely related. A study by Pandey (2012) in rural household in India shows that wood fuel usage, as a source of cooking energy, is the main cause of acute lower respiratory infection and chronic obstructive pulmonary disease. What is more important, it is found that the highest disease burden of acute lower respiratory infection occurs among children. In the same line, this study also suggests that rural poverty rate is positively correlated with wood fuel usage (r=0.4673; p-value=0.000). The more people in rural area better off, the more likely they use healthier source of energy. Rural poor density was also examined in its relation to pneumonia. There is strong association between number of rural poor and pneumonia burden on children less than five years old (r=0.5700; p-value=0.0000). Taking these values in logarithm provides stronger correlation (r=0.6794; p-value=0.0000)[2].

[2]Two different kinds of poverty measurements were chosen considering the scale of the environmental indicators. The rate of the poor was decided to include in the analysis since at the provincial level the data of household using wood fuel is not in its level rather is in proportion. The argument lies in its purpose to get greater magnitude of correlation following the results of the relations in forest context above.



Source: Author's computation

Figure 10 Scatterplot between rural poor and pneumonia

5.2.3. Poverty and environmental risk and vulnerability

Descriptive Statistics

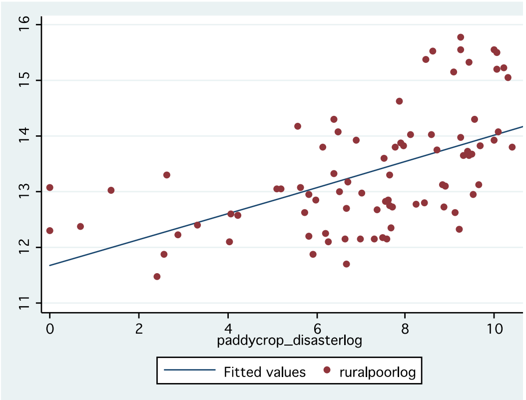
Table 5 Descriptive statistics of poverty and environmental vulnerability

Variable	Obs.	Mean	SD	Min	Max
Rural poverty density (log)	90	13.365	1.029	11.479	15.794
Environmental risks	87	7.246	2.475	0	10.773
Forest coverage	48	32.810	17.224	3.766	62.017

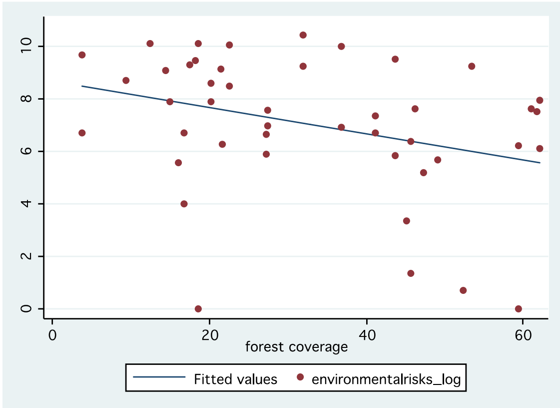
Source: Author's computation

Number of hectares of paddy crop affected by flood and drought as indicator of environmental risks ranged between 1 and 47754 with mean of 6741.184, while rural poverty density ranged between 96700 and 7238900 people with mean of 1152773 people. Lampung province has the highest mean of environment risks exposure that is 21,594 hectares while the highest poverty density is in East Java of 5,833,400 poor people. In order to obtain relationship between poverty and environmental risks and vulnerability, Pearson correlation was employed. This paper uses poverty density as the variable as it purposes to seek whether high concentration of the poor correlates with high environmental risks and vulnerability. It shows highly association between rural poverty density and number of paddy crop area affected by flood and drought (r=0.4113; p-value=0.0001). Taking them in logarithm also provides higher level of correlation (r=0.5558; p-value=0.0001).

The result above suggests that the poor relatively suffer from the exposure of environmental risks. Given the correlation above, it can be articulated that the number of poor increases in the same direction with an increase of the number of cropland destroyed by natural disaster. Furthermore, according to the definition of UNDP (2007:78) that risks affect everyone but the exposures are not equally distributed. It thus represents the level of vulnerability among people are different. This paper thus can say rural poor have high vulnerability of the environmental disadvantages.



(a)



(b)

Source: Author's computation

Figure 11 Scatterplot between environmental risks and (a) rural poor (b) forest coverage

Sequentially, this study also examined the relation between forest coverage and the prevalent of environmental risks[3]. Pearson correlation and figure 11.b show a significant negative relationship between areas with high forest coverage and the exposure of flood and drought (r=-3222; p-value=0.0309). Owing to the statement of UNDP (2007) that states, "climate change threats illustrate the distinction between risk and vulnerability" and "the processes by which risk is converted into vulnerability in any country are shaped by the underlying state of human development […]. Or in other words, areas with low-level human development tend to have high environmental vulnerability. Thus taking all these prepositions together that is high forest coverage tends to have high poverty rate but low poverty density along with the preposition that high forest coverage tend to have low environmental vulnerability, this study hence can draw a concise conclusion that is the areas of low poverty density though the rate is high tend to have low environmental vulnerability.

5.3. Causality testing for poverty and environment nexus

The second analytical tool that is retained in this paper is causal relationship testing between poverty and environment.

[3]This assessment would be very meaningful for constructing the assumption in discussing the poverty-environmental vulnerability in the following sub chapter

5.3.1. The data and model

This study attempts to test bidirectional causality between forest coverage and rural poverty rate in a provincial panel data. According to Human Development Index (HDI) in 2010, this study classifies provinces into three categories that are high HDI, middle HDI and low HDI provinces. After eliminating DKI Jakarta province that consider as a non-rural area, both high HDI and middle HDI groups have 10 provinces each and 12 low HDI provinces for the period 2000-2010. The list of provinces included in each group is presented in appendix C.1.

The following models are tested to estimate the slope coefficient of both variables which is calculated in logarithm:

$$Rural\ poverty\ rate = \sum_{k=1}^{p} \beta_k Rural\ poverty\ rate_{i,t-k} + \sum_{k=0}^{p} \theta_k Forest\ coverage_{i,t-k} + u_{i,t}$$

$$Forest\ coverage = \sum_{k=1}^{p} \beta_k Forest\ coverage_{i,t-k} + \sum_{k=0}^{p} \theta_k Rural\ poverty\ rate_{i,t-k} + u_{i,t}$$

5.3.2. Testing for non-stationary

Before employing Granger causality procedure for panel data from Hurlin and Venet (2001), the optimum lag length testing is required as the first step to explore causality between rural poverty rate and forest coverage. Since the data set in this study has short time period similar with Erdil and Yetkiner (2004); therefore, in order to avoid the potential of unit root this paper follows their method in differencing the data set. Further, optimum lag length is chosen using Akaike Information Criteria (AIC) started from lag one to lag two since number of observations are not available in the regression more than lag two thus the maximum lag length chosen is lag two.

5.3.3. Causality testing

After optimum lag lengths are chosen, the first step of causality analysis is dealing with the homogenous non-causality testing. The null hypothesis is constructed to prove the preposition of forest coverage does not cause rural poverty rate. In an opposite direction, this test also deals with the nullity hypothesis of rural poverty rate does not cause forest coverage. Both hypotheses are imposed collectively for all cross sections to obtain collective non-causality.

The F-statistics for homogeneous non-causality, F_{HNC}, is also presented in Table 6. The first homogeneous non-causality testing is to test causal relationship of forest coverage to rural poverty rate. The results suggest insignificant F_{HNC}, which means there does not exist a homogenous causality from forest coverage to rural poverty rate for all province and all groups. On the contrary, second homogeneous non-causality tests negative preposition of rural poverty rate does not cause forest coverage. The results show overall causal relations from rural poverty rate to forest coverage that present for all provinces and all groups. All rejections in the first step lead us to go through the next step for testing whether the causality presents homogeneously for all provinces or whether there is at least one province has no causality. This test is namely homogenous causality testing.

The F-statistics for homogenous causality, F_{HC} is also given in table 6. The results suggest us that the null hypotheses for homogeneous causality for all provinces and all groups are failed to reject. Hence, the statistical result suggests to stop the causality testing until only the second step.

Table 6 Test result for homogeneous non-causality (HNC) and homogeneous causality (HC) hypotheses

Category	Lag	F_{HNC}	F_{HC}
Causality from forest coverage to rural poverty rate			
All provinces	Lag 1	0.3429	
All provinces[wop]	Lag 1	0.0872	
High HDI	Lag 1	0.1590	
Middle HDI	Lag 1	0.3939	
Low HDI	Lag 1	1.0999	
Low HDI[wop]	Lag 1	0.3828	
Causality from rural poverty rate to forest coverage			
All provinces	Lag 2	2.2141***	0.1360
All provinces[wop]	Lag 2	2.2025***	0.1425
High HDI	Lag 2	2.7637***	0.4336
Middle HDI	Lag 2	2.4968***	0.2512
Low HDI	Lag 2	4.0493***	0.6077
Low HDI[wop]	Lag 2	3.9804***	0.6158

Source: Author's computation

wop: Papua and West Papua are eliminated from the data set
F_{HNC} : F-statistics of homogeneous non causality
F_{HC}: F-statistics of homogeneous causality
Source: Author's computation

Analysing the cause and effect with eliminating Papua and West Papua results in a consistent outcomes. That is the causal link only presents in direction from rural poverty rate to forest coverage and not in the way around.

5.4. Poverty-environment index

Correlation between poverty and environment has been seen in forest context, health and environmental risks through aggregate correlation across provinces and time. Further, causality testing also only revealed causal relationship across provinces and groups of HDI categories. However, the difference variation of poverty and environment performances across provinces and time has not explored yet. Hence, poverty and environment index is developed in order to look forward the state of poverty environment nexus for each province in a point a time and over time. Again, this study examines forest coverage and rural poverty rate as proxies for environment vulnerability and poverty vulnerability.

Environmental vulnerability that is measured in this paper is constructed under the assumption of the higher the forest coverage, the lower the environment vulnerability. Conversely, for measuring poverty vulnerability the assumption is the higher the rural poverty rate, the higher the poverty vulnerability. Since both variables use assumptions in different direction, thus to have meaningful comparison the following formulas are estimated following (Agarwal 1997, Joarder and Hakim 2012).

$$E_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - min x_{ij}}$$

$$P_{ij} = 1 - \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - min x_{ij}}$$

$$PE_{ij} = \frac{E_{ij} + P_{ij}}{2}$$

where E_{ij} represents environmental vulnerability, P_{ij} represents poverty vulnerability and PE_{ij} represents poverty-environment vulnerability.

The regional differences in poverty and environment performances is presented below in order to measure the poverty and environment vulnerability among provinces and across time. The measurement of poverty and environment indices is started from 2002 to 2010 considering the availability data of Papua that is absence prior to 2002.

Regional variations in poverty vulnerability in 2002 and 2010

The regional differences in rural poverty rate among provinces in 2002 ranged widely from 8.3 percent in Bali compared to 51.2 percent in Papua. In 2010, Papua remains in a place with the highest poverty rate although the rate has been decreasing to 46 percent. Gorontalo and North Maluku are considered as provinces with moderate poverty vulnerability in 2010 given poverty indices of 0.63 and 0.70, respectively. Out of these provinces are falling in low poverty vulnerability in 2010. However, omitting Papua and West Papua from the measurement has led to a shifting the number of provinces from low level into moderate rank such as Yogyakarta, Lampung, NAD, East Nusa Tenggara, Central Sulawesi and Southeast Sulawesi. The poverty vulnerability in 2002 and 2010 across provinces is given in Appendix B.3

Regional variations in environment vulnerability in 2002 and 2010

The regional patterns of environment vulnerability in appendix B.4 shows high range of forest coverage across provinces. In 2002, Papua has the highest percentage forested land compared to Yogyakarta that is 72.33 percent and 3.77 percent, respectively. Similarly in 2010, West Papua constitutes as a province with the highest shared of forested land compared to Lampung that is 87.08 percent and 9.08 percent, respectively. Appendix B.4 also shows that all provinces in Java Island have high environment vulnerability. Furthermore, when Papua and West Papua are excluded from the observations in 2002, some provinces altered from high into moderate vulnerability leaving provinces in Java Island keep in high vulnerability place.

Regional variations in poverty-environment vulnerability in 2002 and 2010

Given various single poverty vulnerability and environment vulnerability across provinces, thus taking both indicators of rural poverty rate and forest coverage in the measurement gives us the aggregate indices in poverty-environment vulnerability. Calculating the poverty-environment index in 2002, Yogyakarta is the most vulnerable province showing the highest poverty-environment index of 0.71 while Central Kalimantan has the lowest index of 0.15. Further, Yogyakarta has shifted in 2010 becoming the moderate level of index leaving no provinces falling in high vulnerability.

Omitting Papua and West Papua in poverty-environment index 2002 measurement results in placing of Yogyakarta and East Nusa Tenggara to be high vulnerable provinces with 0.76 and 0.71, respectively, leaving all the moderate provinces remains in the same range. Oppositely, taking Papua and West Papua out from the computation also implies similar outcomes for Yogyakarta to have high index in 2010 compounded by Lampung. Appendix B.5 shows the poverty-environment index.

Regional variations in temporal shift of poverty-environment vulnerability over 2002-10

For changes over time, Appendix B.6 gives an idea of provincial performances on tackling the poverty and environment vulnerability over 2002-10. Its degree in temporal shifts can be an improvement, which is indicated by positive degree and vice versa. Measurement poverty-environment index across province and inter-temporally results in various performances. Consider all provinces as observations, the greatest inter-temporal differences was in Maluku and Central Sulawesi. Both provinces have made very good performance on reducing the poverty environment gap by 0.22. In contrast, Bengkulu made null progress on reducing the poverty-environmental risk. Similarly numbers of provinces also have very low progress including West Java, Lampung and Bali. However, in between come provinces with moderate progress such as Papua that has reduced the gap by 0.11.

Since it is known that Papua and West Papua have an exceptional degrees of vulnerability, thus as it is expected that excluding those provinces will give a notable different result in inter-temporal shift performance. Most provinces that previously consider having low marginal progress now have shifted to be in a place with higher degree of progress. Jambi, Yogyakarta, and East Nusa Tenggara, for instances, now consider to have greater performance compared to the result when including Papua and West Papua.

Environmental vulnerability: Connection with HDI

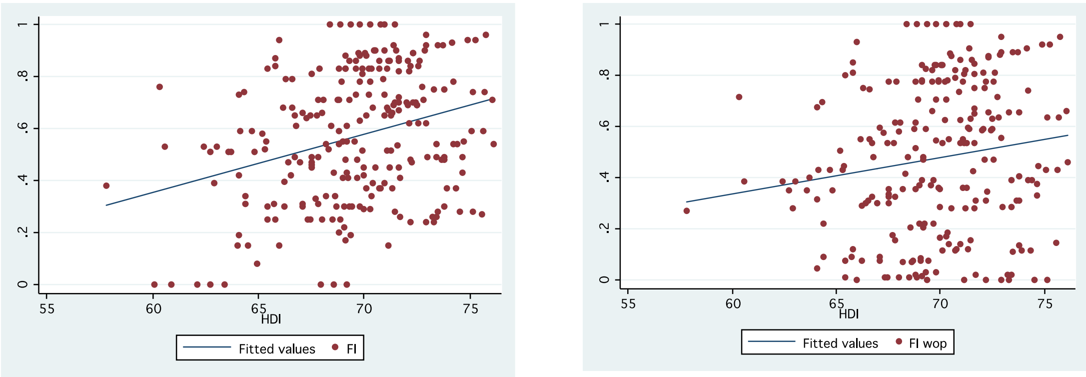
As this paper has shown causal relation from rural poverty to forest coverage for all categories of HDI, thus it is worthy to see the magnitude of relationship between HDI and environmental risk. Pearson correlation shows that both indicators are positively correlated (r=0.2974; p-value=0.0000). This result gives an idea of high living standard correlates with high environmental risk. Eliminating Papua and West Papua results in a lower magnitude of correlation (r=0.1551; p-value=0.0176). This case is due to both provinces are considered as outliers; therefore, taking them out from the computation will smooth the individual index in each province and lesser the magnitude of correlation (figure 13).

Table 7 Descriptive statistics of environmental vulnerability and HDI

Variable	Obs.	Mean	SD	Min	Max

HDI	253	69.513	3.368	57.8	76.09
FI-a	274	0.566	0.253	0	1
FI-b	262	0.478	0.293	0	1

Source: Author's computation



(a) (b)

Source: Author's computation

Figure 12 Scatterplot between environmental vulnerability and HDI (a) all provinces (b) excluding Papua and West Papua

5.5. Summary and discussion

Three hypotheses were formulated for this study. For all three hypotheses, several indicators measured were: forest coverage, rural poverty rate and density, health problem and environmental risks. In the following sub section the main findings are reviewed for each hypothesis and also several suggestions concerning policy implication and future research are made.

5.5.1. Interconnection of poverty and environmental key indicators-hypothesis 1

1. Summary of result

The first hypothesis argued that indicators of poverty and environment are interconnected. It was fully supported by our evidence that forest coverage is positively correlated with rural poverty rate although negatively correlated with rural poor density. To get more deeper into the interconnection, the poor are also those who highly dependent on solid fuel. Pneumonia on children as expected was also highly correlated with the poor. Similar concept was drawn for environmental risks such as flood and drought, as it is expected; the environmental vulnerability from flood and drought was also related to the concentration of the poor.

2. Discussion and implication

Several literatures have indicated that forested area and incidence of poverty are highly bounded (Sunderlin et al. 2008:18, Muller et al. 2006). Furthermore, Sunderlin et al. explain that due to "primordial poverty" in forested land that is a living mode in a subsistence level and due to lack of power of forest dwellers in economics and political opportunities have led poverty in remote areas to be chronic and hard to cope with. Besides, forest dwelling people also constraint for having investment in development process due to remoteness of the area.

Examining the state of poverty and environment relations in Indonesia provides an evidence of the nexus. First, although only few numbers of people live in high-forested land, however, the rate is relatively high. For instances, Papua and West Papua. Conversely, Bali and other provinces in Java Island and some in Sumatera also represent highly correlation between low forest coverage and low poverty rate. Given these pictures of correlation; however, this paper does not suggest that reducing the area of forested land would alleviate poverty. That is not the case. Rather these findings appear to suggest that the nature of the rural poverty would imply to the forest coverage performance.

Furthermore, it should be noted that the poor suffer from pneumonia prevalence in rural area due to less healthy energy source. Hence, it is possible to withdraw the assessment of government program on providing LPG (liquefied petroleum gas) as healthier cooking energy sources incorporating with poverty alleviation program. However, it is important that future research considers the possible relationship between the program and the poor health performance along with the examination of the change of their dependency on environment.

A final point with regard to interconnection of poverty-environment indicators is that the vulnerability of the poor to have environmental shock such as flood and drought is proven. This paper suggests, by virtue of the fact that the rural poor have been living in agricultural society, these shocks might danger their livelihood. This finding recommends that policy interventions such as building social security fund for those who suffer from natural disaster might be helpful in minimizing vulnerability of the poor.

5.5.2. Causality of poverty and environmental key indicators-hypothesis 2

1. Summary of result

Hypothesis two competed with the debate of the vicious circle of poverty-environment nexus. The causality finding is also congruent with the previous result that is causal relationship from rural poverty rate to forest coverage and is not on the way around.

2. Discussion and implication

Interpreting the result of hypothesis two is the main challenge. To discuss about the result, it would be helpful if we build a question: what is the role of poverty for the environment? The answer of this hypothesis was partially supported by the World Bank report that shows the remote areas with high forest cover there is also high poverty rates and low poverty density (Chomitz and Buys 2007:84). They present an argument of low poor density leads to draw low investment. The cost for deliver infrastructure and other public facilities, for instance, become much more higher. Thus it is difficult to have inclusive growth in such remote areas. Consequently, due to its remoteness from markets thus harvesting timber, opening forested land for agriculture and growing crop are rarely. Therefore, the remote areas with low poor density though the rate is high tend to have low rates of deforestation and then the forest cover remains high.

Another partial support was found in Lambin et al. (2001:263). That states considering population growth or poverty solely as a cause of deforestation is rather simplification of the complex task. Rather, there are social, political and infrastructural factors that trigger land use and land cover. From the perspective of this study, a key further question that can be drawn is whether those microeconomics problems, social and political triggers can address macroeconomic difficulties and support inclusive growth of the endogenous inhabitant or whether those development drivers only fuel the urban people to migrate and destroy the environment.

5.5.3. Poverty and environmental key indicators vary among regions-hypothesis 3

1. Summary of result

Hypothesis three examined the variability of poverty-environment vulnerability across provinces and times. The expectation was sequentially built from the result in hypothesis two that is providing empirical evidences within country. Regions with high poverty performance will tend to have high forest vulnerability. This paper thus went through to the measurement of poverty-environment indices to reveal individual progress on alleviating poverty and environment vulnerability.

2. Discussion and implication

The last step for assessing the nexus between rural poverty and forest coverage is measurement poverty-environment index. These inter-temporal indices indicate that areas, which have low marginal progress on alleviating poverty, are the areas of high poverty rate and low poverty density. These areas also constitute high-forested land. The example for this case is West Papua and North Maluku. Conversely, Yogyakarta and Banten, which have low forest coverage with low poverty rate and high poverty density, tend to have a notable progress on reducing the poverty vulnerability. This hypothesis was also fully supported, again, by restating from Chomitz and Buys (2007:87), "The remoteness connection points to a distinct poverty-forest syndrome." Moreover, "But some forest areas suffer from poverty because their remoteness from agricultural markets and because low population densities make it difficult to deliver services and infrastructure" (ibid:88).

In addition, the overall focus of this study was on the rather specific nature of poverty and environment. By examining the link between environment vulnerability and HDI, as it is expected that areas of high environment index are the areas with high HDI. This additional result also encompasses the same expectation of previous hypotheses. However, replication or extension of this kind of study may find stronger result of the state of poverty and environment nexus if use longer-term period to generate more robust changes in poverty-environment performances. In spite of time limitation of this study, the overall findings stated above still provide an indication of the importance of policy makers to consider the state of poverty into environmental programs particularly forest conservation.

Chapter 6
Summary and conclusion

Understanding poverty and environment nexus is a challenge. A rich literature has applied quantitative methods to different poverty and environment concepts in different countries reaching in different conclusions. Considering the state of rural poverty compounded by divergence environmental condition the study was expected to address the need to observe the nexus of poverty and environment in Indonesia context by applying three different methodologies.

From testing the correlation between poverty and environment, there are several main conclusions of the poverty and environment nexus in Indonesia. Evidences on poverty and forest context shows that the rural poverty and forest are correlated. It is also shown that the rural poor are highly dependence on solid fuel availability. Moreover, there is also evidence that the poor suffer from respiratory health problem related to poor energy sources. In term of vulnerability, it is found that poverty is highly concurrent with environmental risks making them more vulnerable to be impoverished.

After establishing that rural poverty and forest coverage are associated from correlation test, causality testing was applied as the sequential step. Taking all provinces in the data set excluding DKI Jakarta in time period of 2001-10 results in non-bidirectional causality i.e. only one direction link, from poverty to environment. To be more detailed, there is homogeneous causality for all provinces. Even though Papua and West Papua have been omitted from the observation, the cause and effect relationship remains similar.

In order to find evidences of the poverty and environment nexus in particular provinces, the study went through the third step that is discovering the poverty and environment vulnerability for each province. In order to comprehend the individual nexus in a particular provinces and a point of time, inter-temporal indices were calculated to show the shift of the poverty and environment vulnerability over years. The study showed that large numbers of provinces only have few progress of reducing the joint vulnerability. Finally, additional information from environment index and HDI has given insightful idea of coincidence between the areas with higher HDI and the areas with the higher environment vulnerability.

Given the result summary of this research above, this paper has been added a new insight of poverty-environment nexus into the contention of literatures about the state of poverty and environment links. As rural communities face some disadvantages of development with respect to socio-economic obstacles; owing to an example given by Chomitz and Buys (2007:85) that the disadvantage of rural poor is decreasing tenure security with remoteness, Pellegrini (2009:11) shows "formal consensus" that forestry policy should address not only sustainable natural resources management but also social objectives including "endowment and entitlements to marginal communities". These perspectives support the suggestion of this paper that forestry policies need to be constructed by strengthen the poor economically, socially and institutionally.

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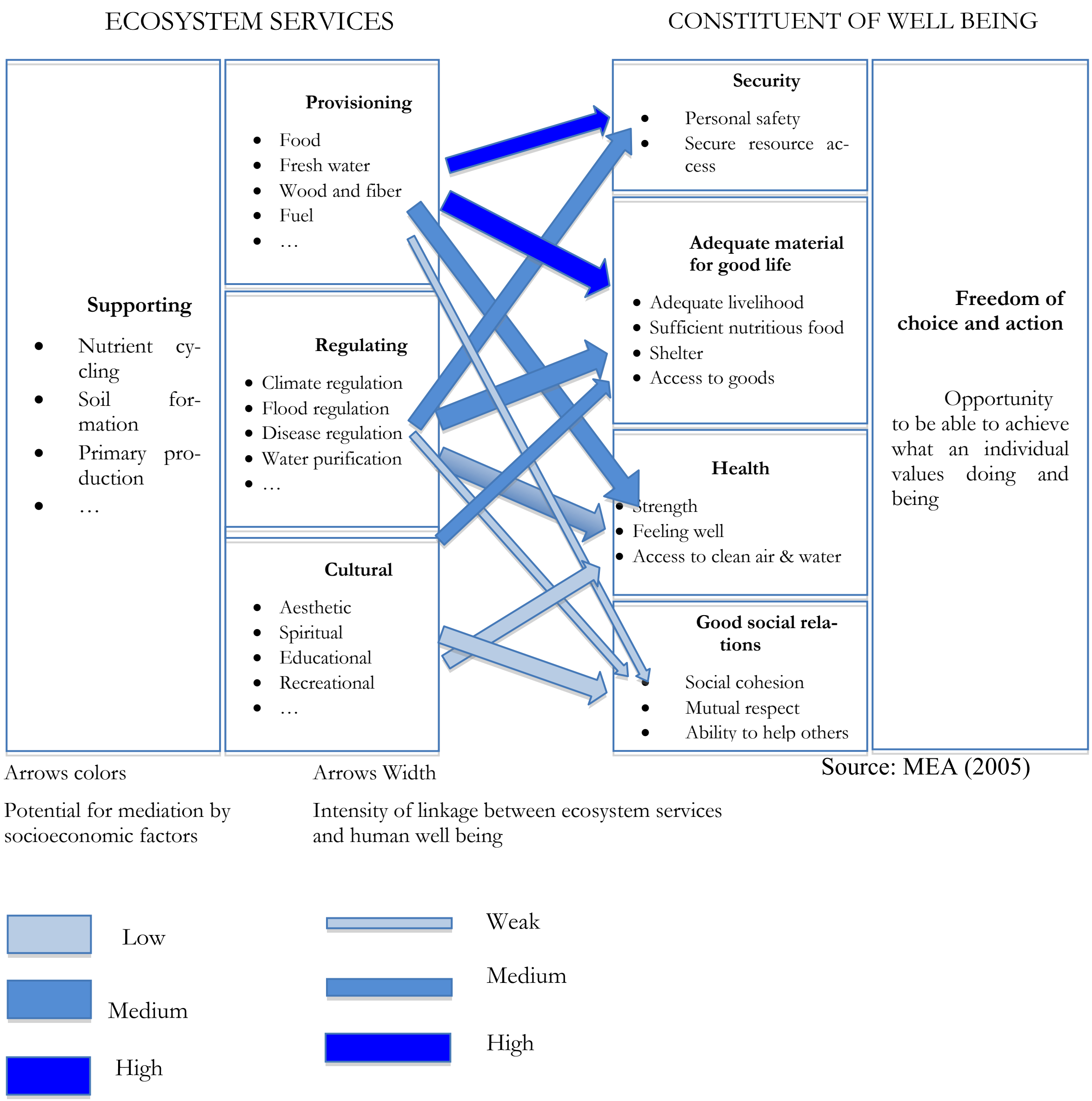
Appendices

Appendix A. The linkage between ecosystem services and human well-being



Source: MEA (2005)

Appendix B

Appendix B.1 Poverty and environment indices 2002-10 with and without Papua and West Papua

	Indices 2002-a			Indices 2002-b			Indices 2010-a			Indices 2010-b		
Province	FI	PI	PEI	FI	PI	PEI	FI	PI	PEI	FI	PI	PEI
Bali	0.81	0.00	0.41	0.78	0.00	0.39	0.89	0.01	0.45	0.87	0.01	0.44
Banten	0.79	0.10	0.44	0.75	0.13	0.44	0.90	0.12	0.51	0.88	0.17	0.53
Bengkulu	0.40	0.31	0.35	0.29	0.38	0.34	0.62	0.31	0.46	0.56	0.44	0.50
Yogyakarta	1.00	0.41	0.71	1.00	0.51	0.76	0.96	0.40	0.68	0.95	0.58	0.76
West Papua	0.19	0.63	0.41				0.29	0.63	0.46			
Gorontalo				0.05	0.79	0.42	0.00	0.94	0.47	0.17	0.89	0.53
Jambi	0.66	0.06	0.36	0.59	0.07	0.33	0.76	0.02	0.39	0.72	0.04	0.38
West Java	0.84	0.11	0.48	0.81	0.14	0.47	0.89	0.20	0.55	0.88	0.29	0.58
Central Java	0.79	0.39	0.59	0.75	0.48	0.62	0.69	0.32	0.50	0.63	0.46	0.55
East Java	0.73	0.37	0.55	0.68	0.46	0.57	0.70	0.35	0.52	0.65	0.50	0.57
West Kalimantan	0.39	0.15	0.27	0.28	0.19	0.23	0.55	0.11	0.33	0.47	0.16	0.31
South Kalimantan	0.74	0.03	0.39	0.69	0.04	0.37	0.81	0.00	0.41	0.78	0.00	0.39
Central Kalimantan	0.17	0.13	0.15	0.02	0.16	0.09	0.43	0.06	0.25	0.33	0.09	0.21
East Kalimantan	0.29	0.31	0.30	0.17	0.39	0.28	0.27	0.20	0.23	0.15	0.28	0.22
Bangka Belitung	0.83	0.11	0.47	0.80	0.13	0.47	0.90	0.07	0.48	0.88	0.10	0.49
Kepulauan Riau							0.70	0.06	0.38	0.65	0.09	0.37
Lampung	0.87	0.38	0.63	0.85	0.47	0.66	1.00	0.37	0.69	1.00	0.53	0.77
Maluku	0.42	0.80	0.61	0.31	1.00	0.66	0.28	0.70	0.49	0.15	1.00	0.58
North Maluku	0.25	0.14	0.20		0.17		0.22	0.16	0.19	0.09	0.23	0.16
NAD	0.15	0.58	0.36		0.72		0.41	0.44	0.43	0.31	0.63	0.47
West NT	0.38	0.36	0.37	0.27	0.45	0.36	0.58	0.28	0.43	0.51	0.39	0.45
East NT	0.76	0.56	0.66	0.72	0.70	0.71	0.64	0.48	0.56	0.58	0.69	0.63
Papua	0.00	1.00	0.50				0.08	1.00	0.54			
Riau	0.48	0.25	0.36	0.39	0.30	0.35	0.71	0.11	0.41	0.66	0.16	0.41
West Sulawesi							0.48	0.24	0.36	0.39	0.35	0.37
South Sulawesi	0.52	0.26	0.39	0.43	0.33	0.38	0.72	0.23	0.47	0.67	0.33	0.50
Central Sulawesi	0.34	0.42	0.38	0.22	0.52	0.37	0.15	0.36	0.25	0.00	0.52	0.26
Southeast Sulawesi	0.42	0.46	0.44	0.31	0.57	0.44	0.45	0.38	0.41	0.36	0.54	0.45
North Sulawesi	0.66	0.16	0.41	0.60	0.20	0.40	0.54	0.11	0.33	0.46	0.16	0.31
West Sumatera	0.45	0.06	0.26	0.36	0.07	0.22	0.49	0.13	0.31	0.41	0.18	0.30
South Sumatera	0.94	0.32	0.63	0.93	0.40	0.67	0.96	0.22	0.59	0.95	0.32	0.64
North Sumatera	0.59	0.22	0.40	0.52	0.27	0.39	0.78	0.14	0.46	0.74	0.20	0.47
Mean	0.551	0.317	0.434	0.523	0.364	0.442	0.587	0.281	0.437	0.576	0.343	0.453
SD	0.259	0.239	0.134	0.283	0.252	0.177	0.281	0.245	0.126	0.289	0.25	0.152

- Source: Author's own computation
- FI: environment index
- PI: poverty index
- PEI: poverty and environment index
- a: all observatios
- b: without Papua and West Papua

Appendix B. 2 Temporal shift of F(T), P(T) and PE(T) over 2001-10

Province	FT (a)	PT (a)	PET (a)	FT (b)	PT (b)	PET (b)
Bali	0.01	0.11	0.06	0.02	0.11	0.06
Banten	-0.01	0.25	0.12	-0.01	0.25	0.12
Bengkulu	-0.07	0.17	0.05	-0.09	0.17	0.04
Yogyakarta	0.10	0.35	0.22	0.12	0.35	0.23
West Papua	0.06	0.05	0.05			
Gorontalo				0.07	0.05	0.06
Jambi	0.01	0.31	0.16	0.01	0.31	0.16
West Java	0.04	0.17	0.10	0.04	0.17	0.11
Central Java	0.18	0.22	0.20	0.21	0.22	0.22
East Java	0.11	0.18	0.15	0.14	0.18	0.16
West Kalimantan	-0.02	0.26	0.12	-0.02	0.26	0.12
South Kalimantan	0.03	0.21	0.12	0.03	0.21	0.12
Central Kalimantan	-0.09	0.14	0.02	-0.11	0.14	0.01
East Kalimantan	0.15	0.15	0.15	0.17	0.15	0.16
Bangka Belitung	0.06	0.00	0.03	0.07	0.00	0.03
Kepulauan Riau						
Lampung	-0.08	0.14	0.03	-0.10	0.14	0.02
Maluku	0.20	0.19	0.19	0.24	0.19	0.21
North Maluku		0.04			0.04	
NAD	-0.08			-0.10		
West NT	-0.05	0.39	0.17	-0.06	0.39	0.16
East NT	0.20	0.25	0.22	0.24	0.25	0.24
Papua		0.15				
Riau	0.00	0.09	0.04	-0.01	0.09	0.04
West Sulawesi						
South Sulawesi	-0.07	0.11	0.02	-0.08	0.11	0.01
Central Sulawesi	0.33	0.17	0.25	0.39	0.17	0.28
Southeast Sulawesi	0.10	0.18	0.14	0.12	0.18	0.15
North Sulawesi	0.21	0.03	0.12	0.25	0.03	0.14
West Sumatera	0.09	0.14	0.11	0.10	0.14	0.12
South Sumatera	0.04	0.13	0.08	0.04	0.13	0.08
North Sumatera	-0.06	0.08	0.01	-0.08	0.08	0.00
Mean	0.050	0.165	0.113	0.060	0.166	0.118
SD	0.108	0.092	0.070	0.129	0.094	0.078

- Source: Author's own computation
- FT: inter-temporal environment index
- PT: inter-temporal poverty index
- PET: inter-temporal poverty-environment index
- a: all observations
- b: without Papua and West Papua

Appendix B.3 Poverty index in 2002 and 2010

PI 2002-a			PI 2002-b			PI 2010-a			PI 2010-b		
PI<0.5	0.5<=PI<=0.7	PI >0.7	PI<0.5	0.5<=PI<=0.7	PI >0.7	PI<0.5	0.5<=PI<=0.7	PI >0.7	PI<0.5	0.5<=PI<=0.7	PI >0.7
Bali	Gorontalo	Maluku	Bali	Yogyakarta	Gorontalo	Bali	Gorontalo	West Papua	Bali	Yogyakarta	Gorontalo
Banten	NAD	Papua	Banten	Central Sulawesi	Maluku	Banten	Maluku	Papua	Banten	Lampung	Maluku
Bengkulu	East NT		Bengkulu	Southeast Sulawesi	NAD	Bengkulu			Bengkulu	NAD	
Yogyakarta			Jambi		East NT	Yogyakarta			Jambi	East NT	
Jambi			West Java			Jambi			West Java	Central Sulawesi	
West Java			Central Java			West Java			Central Java	Southeast Sulawesi	
Central Java			East Java			Central Java			East Java		
East Java			West Kalimantan			East Java			West Kalimantan		
West Kalimantan			South Kalimantan			West Kalimantan			South Kalimantan		
South Kalimantan			Central Kalimantan			South Kalimantan			Central Kalimantan		
Central Kalimantan			East Kalimantan			Central Kalimantan			East Kalimantan		
East Kalimantan			Bangka Belitung			East Kalimantan			Bangka Belitung		
Bangka Belitung			Lampung			Bangka Belitung			Kepulauan Riau		
Lampung			North Maluku			Kepulauan Riau			North Maluku		
North Maluku			West NT			Lampung			West NT		
West NT			Riau			North Maluku			Riau		
Riau			South Sulawesi			NAD			West Sulawesi		
South Sulawesi			North Sulawesi			West NT			South Sulawesi		
Central Sulawesi			West Sumatera			East NT			North Sulawesi		
Southeast Sulawesi			South Sumatera			Riau			West Sumatera		
North Sulawesi			North Sumatera			West Sulawesi			South Sumatera		
West Sumatera						South Sulawesi			North Sumatera		
South Sumatera						Central Sulawesi					
North Sumatera						Southeast Sulawesi					
						North Sulawesi					

						West Sumatera South Sumatera North Sumatera					

- Source: Author's own computation
- FI 2002-a: environment index all provinces in 2002
- FI 2002-b: environment index without Papua and West Papua in 2002
- FI 2010-a: environment index all provinces in 2010
- FI 2010-b: environment index without Papua and West Papua in 2010

- FI<0.5 low environment vulnerability
- 0.5<=FI<=0.7 moderate environment vulnerability
- FI >0.7 high environment vulnerability

Appendix B.4 Environment index in 2002 and 2010

FI 2002-a			FI 2002-b			FI 2010-a			FI 2010-b		
FI<0.5	0.5<=FI<=0.7	FI >0.7	FI<0.5	0.5<=FI<=0.7	FI >0.7	FI<0.5	0.5<=FI<=0.7	FI >0.7	FI<0.5	0.5<=FI<=0.7	FI >0.7
Bengkulu	Jambi	Bali	Bengkulu	Jambi	Bali	Gorontalo	Bengkulu	Bali	Gorontalo	Bengkulu	Bali
Gorontalo	South Sulawesi	Banten	Gorontalo	East Java	Banten	West Papua	Central Java	Banten	West Kalimantan	Central Java	Banten
West Kalimantan	North Sumatera	Yogyakarta	West Kalimantan	South Kalimantan	Yogyakarta	Central Kalimantan	West Kalimantan	Yogyakarta	Central Kalimantan	East Java	Yogyakarta
Central Kalimantan		West Java	Central Kalimantan	North Sulawesi	West Java	East Kalimantan	West NT	Jambi	East Kalimantan	Kepulauan Riau	Jambi
East Kalimantan		Central Java	East Kalimantan	North Sumatera	Central Java	Maluku	East NT	West Java	Maluku	West NT	West Java
Maluku		East Java	Maluku		Bangka Belitung	North Maluku	North Sulawesi	East Java	North Maluku	East NT	South Kalimantan
North Maluku		South Kalimantan	North Maluku		Lampung	NAD		South Kalimantan	NAD	Riau	Bangka Belitung
NAD		Bangka Belitung	NAD		East NT	Papua		Bangka Belitung	West Sulawesi	South Sulawesi	Lampung
West NT		Lampung	West NT		South Sumatera	West Sulawesi		Kepulauan Riau	Central Sulawesi		South Sumatera
Papua		East NT	Riau			Central Sulawesi		Lampung	Southeast Sulawesi		North Sumatera
Riau		North Sulawesi	South Sulawesi			Southeast Sulawesi		Riau	North Sulawesi		
Central Sulawesi		South Sumatera	Central Sulawesi			West Sumatera		South Sulawesi	West Sumatera		

Southeast Sulawesi			Southeast Sulawesi West Sumatera					South Sumatera North Sumatera			

- Source: Author's own computation
- FI 2002-a: environment index all provinces in 2002
- FI 2002-b: environment index without Papua and West Papua in 2002
- FI 2010-a: environment index all provinces in 2010
- FI 2010-b: environment index without Papua and West Papua in 2010

- FI<0.5 low environment vulnerability
- 0.5<=FI<=0.7 moderate environment vulnerability
- FI >0.7 high environment vulnerability

Appendix B.5 Poverty-environment index in 2002 and 2010

PEI 2002-a			PEI 2002-b			PEI 2010-a			PEI 2010-b		
PEI<0.5	0.5<=PEI<=0.7	PEI >0.7	PEI<0.5	0.5<=PEI<=0.7	PEI >0.7	PEI<0.5	0.5<=PEI<=0.7	PEI >0.7	PEI<0.5	0.5<=PEI<=0.7	PEI >0.7
Bali	Central Java	Yogyakarta	Bali	Central Java	Yogyakarta	Bali	Banten		Bali	Banten	Yogyakarta
Banten	East Java		Banten	East Java	East NT	Bengkulu	Yogyakarta		Bengkulu	Gorontalo	Lampung
Bengkulu	Lampung		Bengkulu	Lampung		Gorontalo	West Java		Jambi	West Java	
Gorontalo	Maluku		Gorontalo	Maluku		West Papua	Central Java		West Kalimantan	Central Java	
Jambi	East NT		Jambi	South Sumatera		Jambi	East Java		South Kalimantan	East Java	
West Java	Papua		West Java			West Kalimantan	Lampung		Central Kalimantan	Maluku	
West Kalimantan	South Sumater		West Kalimantan			South Kalimantan	East NT		East Kalimantan	East NT	
South Kalimantan			South Kalimantan			Central Kalimantan	Papua		Bangka Belitung	South Sumater	
Central Kalimantan			Central Kalimanta			East Kalimantan	South Sumatera		Kepulauan Riau		
East Kalimantan			East Kalimantan			Bangka Belitung			North Maluku		
Bangka Belitung			Bangka Belitung			Kepulauan Riau			NAD		
North Maluku			North Maluku			Maluku			West NT		
NAD			NAD			North Maluku			Riau		
West NT			West NT			NAD			West Sulawesi		
Riau			Riau			West NT			South Sulawesi		
South Sulawesi			South Sulawesi			Riau			Central Sulawesi		
Central Sulawesi			Central Sulawesi			West Sulawesi			Southeast Sulawesi		
Southeast Sulawesi			Southeast Sulawes			South Sulawesi			North Sulawesi		
North Sulawesi			North Sulawesi			Central Sulawesi			West Sumatera		

West Sumatera			West Sumatera			Southeast Sulawesi			North Sumatera		
North Sumatera			North Sumatera			North Sulawesi					
						West Sumatera					
						North Sumatera					

- Source: Author's own computation
- PEI 2002-a: environment index all provinces in 2002
- PEI 2002-b: environment index without Papua and West Papua in 2002
- PEI 2010-a: environment index all provinces in 2010
- PEI 2010-b: environment index without Papua and West Papua in 2010

- PEI<0.5 low environment vulnerability
- 0.5<=PEI<=0.7 moderate environment vulnerability
- PEI>0.7 high environment vulnerability

Appendix B.6 Temporal shift of poverty index over 2002-10

PE(T)-a					PE(T)-b				
<=0.05	>0.05-<=0.10	>0.10-<=0.15	>0.15-<=0.20	>0.20	<=0.05	>0.05-<=0.10	>0.10-<=0.15	>0.15-<=0.20	>0.20
Bali	Yogyakarta	East Java	Central Java	Maluku	Bali	Gorontalo	Yogyakarta	Central Java	Maluku
Banten	Gorontalo	North Maluku	East Kalimantan	Central Sulawesi	Banten	Jambi	East Java	East Kalimantan	East NT
Bengkulu	South Kalimantan	Papua	East NT		Bengkulu	West Kalimantan	North Maluku	North Sulawesi	Central Sulawesi
Jambi	Bangka Belitung	Southeast Sulawesi	North Sulawesi		West Java	South Kalimantan	Southeast Sulawesi		
West Java	NAD	South Sumatera			Central Kalimantan	Bangka Belitung	South Sumatera		
West Kalimantan					Lampung	NAD			
Central Kalimantan					South Sulawesi	West NT			
Lampung					North Sumatera	Riau			
Riau						West Sumatera			
South Sulawesi									
West Sumatera									
North Sumatera									
West NT									
South Sulawesi									
West Sumatera									
North Sumatera									

- Source: Author's own computation
- PE(T)-a: temporal poverty-environment index all provinces over 2002-10
- PE(T)-b: temporal poverty-environment index without Papua and West over 2002-10

Appendix C

Appendix C.1 Provinces in data set

High HDI	Middle HDI	Low HDI
North Sulawesi	Bangka Belitung	Central Sulawesi
Riau	Jambi	Banten
Yogyakarta	Central Java	Gorontalo
East Kalimantan	West Java	Southeast Sulawesi
Kepulauan Riau	Bali	West Sulawesi
Central Kalimantan	NAD	South Kalimantan
North Sumatera	East Java	West Kalimantan
West Sumatera	South Sulawesi	West Papua
South Sumatera	Lampung	North Maluku
Bengkulu	Maluku	West Nusa Tenggara
		East Nusa Tenggara
		Papua

Source: Author's own selection based on HDI 2010

Appendix C.2 Correct model specification testing for all provinces

Model	Calculated F-stat	Prob F>Critical	AIC	BIC	Decision
Forest coverage (First Difference)					
Drift and Trend	301.42	0.0000	1336.275	1346.692	For N=238, F-table=6.34 Reject → Trend model
Random Walk with Drift	302	0.0000	1334.355	1341.299	For N=238, F-table=4.63→Reject
Rural poverty rate (First Difference)					
Drift and Trend	681.02	0.0000	288.5859	296.9232	For N=119, F-table=6.49→Reject → trend
Random Walk with Drift*	755.52	0.0000	286.616	292.1742	For N=119, F-table=4.71

Source: Author's own computation

Appendix C.3 Correct model specification testing for high HDI provinces

Model	Calculated F-stat	Prob F>Critical	AIC	BIC	Decision
Forest coverage (first difference)					
Drift and Trend*	43.97	0.0000	411.6976	418.5689	For N=73, F-table= 6.49→Reject → trend model
Random Walk with Drift	43.16	0.0000	411.1035	415.6845	For N=73, F-table =4.71 → reject
Rural poverty rate (first difference)					
Drift and Trend	215.86	0.0000	95.13598	100.0487	N=38, F-table = 7.24→reject → trend model
Random Walk with Drift*	228.03	0.0000	93.13599	96.41116	N=38, F-table=5.18→reject

Source: Author's own computation

Appendix C.4 Correct model specification testing for middle HDI provinces

Model	Calculated F-stat	Prob F>Critical	AIC	BIC	Decision
Forest coverage (first Difference)					
Drift and Trend	96.16	0.0000	415.2494	422.3955	For N=80, Ftable=6.49→ Reject
Random Walk with Drift	94.06	0.0000	416.193	420.957	For N=90→F-table=4.71
Rural poverty rate (first Difference)					
Drift and Trend	212.88	0.0000	92.93772	97.92841	For N=39, F-table= 6.73→reject
Random Walk with Drift*	236.39	0.0000	92.24726	95.57438	For N=59, F-table=4.86→reject

Source: Author's own computation

Appendix C.5 Correct model specification testing for low HDI provinces

Model	Calculated F-stat	Prob F>Critical	AIC	BIC	Decision
Forest coverage (first difference)					
Drift and Trend	142.68	0.0000	505.7084	513.0363	For N=85, f-table 6.49 →Reject→ trend
Random Walk with Drift	145.73	0.0000	503.7502	508.6355	For N=85, f-table 4.71
Rural poverty rate (first Difference)					
Drift and Trend	230.31	0.0000	108.3846	113.5976	For N=42, f-table 6.73 →Reject trend
Random Walk with Drift*	11.79	0.0000	-251.3369	-246.4992	For N=42, f-table 4.86

Source: Author's own computation

Appendix D

Appendix D.1 Optimum lag length selection for all provinces

No. of Lags	Calculated F-stat	Prob F>Critical	AIC	BIC
Rural poverty rate (First Difference)				
0	680.91	0.0000	288.5859	296.9232
1*	65.00	0.0000	96.01297	**297.2564**
Forest coverage (First Difference)				
0	301.42	0.0000	1336.275	1346.692
1	51.84	0.0000	1182.459	**1195.771**
2*	56.53	0.0000	940.8154	956.6678
3	15.28	0.0000	809.8928	827.7945

- Source: Author's own computation
- * Selected lag lengths are highlighted and the selection is done on the basis of the lowest information criteria (AIC) and the possibility of observation (more than lag 2 there is no observation).

Appendix D.2 Optimum lag length selection for high HDI provinces

No. of Lags	Calculated F-stat	Prob F>Critical	AIC	BIC
Rural poverty rate (first difference)				
0	215.86	0.0000	95.13598	**100.0487**
1*	40.09	0.0000	21.79963	**25.57739**
2	1.18	0.3599	23.30333	28.02552
Forest coverage (first difference)				
0	43.97	0.0000	411.6976	418.5689
1	18.41	0.0000	360.796	**369.3686**
2*	16.06	0.0000	298.8101	308.755
3	6.57	0.0002	259.5054	270.3454

- Source: Author's own computation

- * Selected lag lengths are highlighted and the selection is done on the basis of the lowest information criteria (AIC) and the possibility of observation (more than lag 2 there is no observation).

Appendix D.3 Optimum lag length selection for middle HDI provinces

No. of Lags	**Calculated F-stat**	**Prob F>Critical**	**AIC**	**BIC**
Rural poverty rate (first difference)				
0	212.83	0.0000	92.93772	97.92841
1*	13.09	0.0002	23.97366	**27.75141**
Forest coverage (first difference)				
0	96.15	0.0000	415.2494	422.3955
1	18.71	0.0000	374.2069	**383.2008**
2*	21.78	0.0000	294.6123	305.084
3	6.29	0.0000	256.7692	268.2413

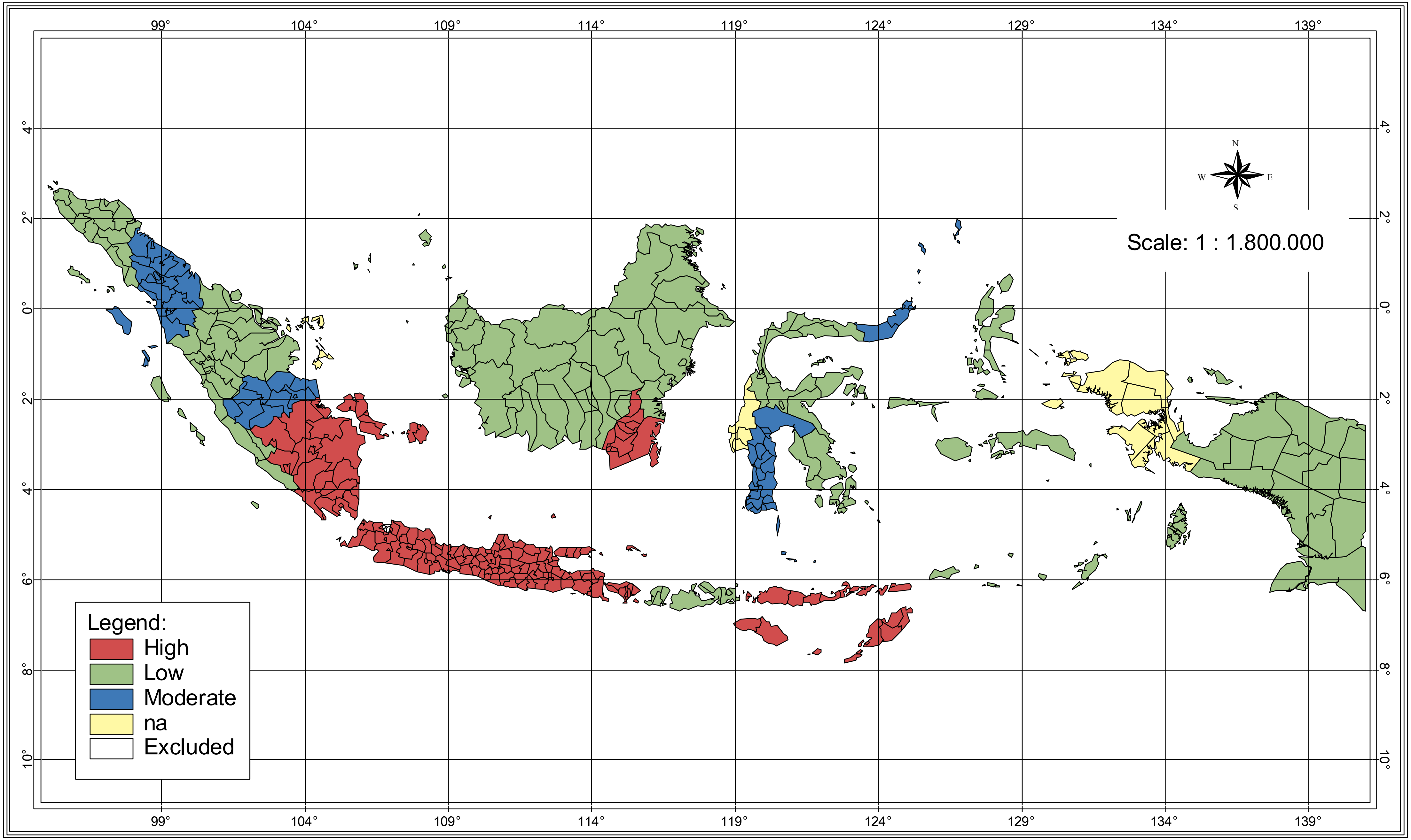
- Source: Author's own computation
- * Selected lag lengths are highlighted and the selection is done on the basis of the lowest information criteria (AIC) and the possibility of observation (more than lag 2 there is no observation).

Appendix D.4 Optimum lag length selection for low HDI provinces

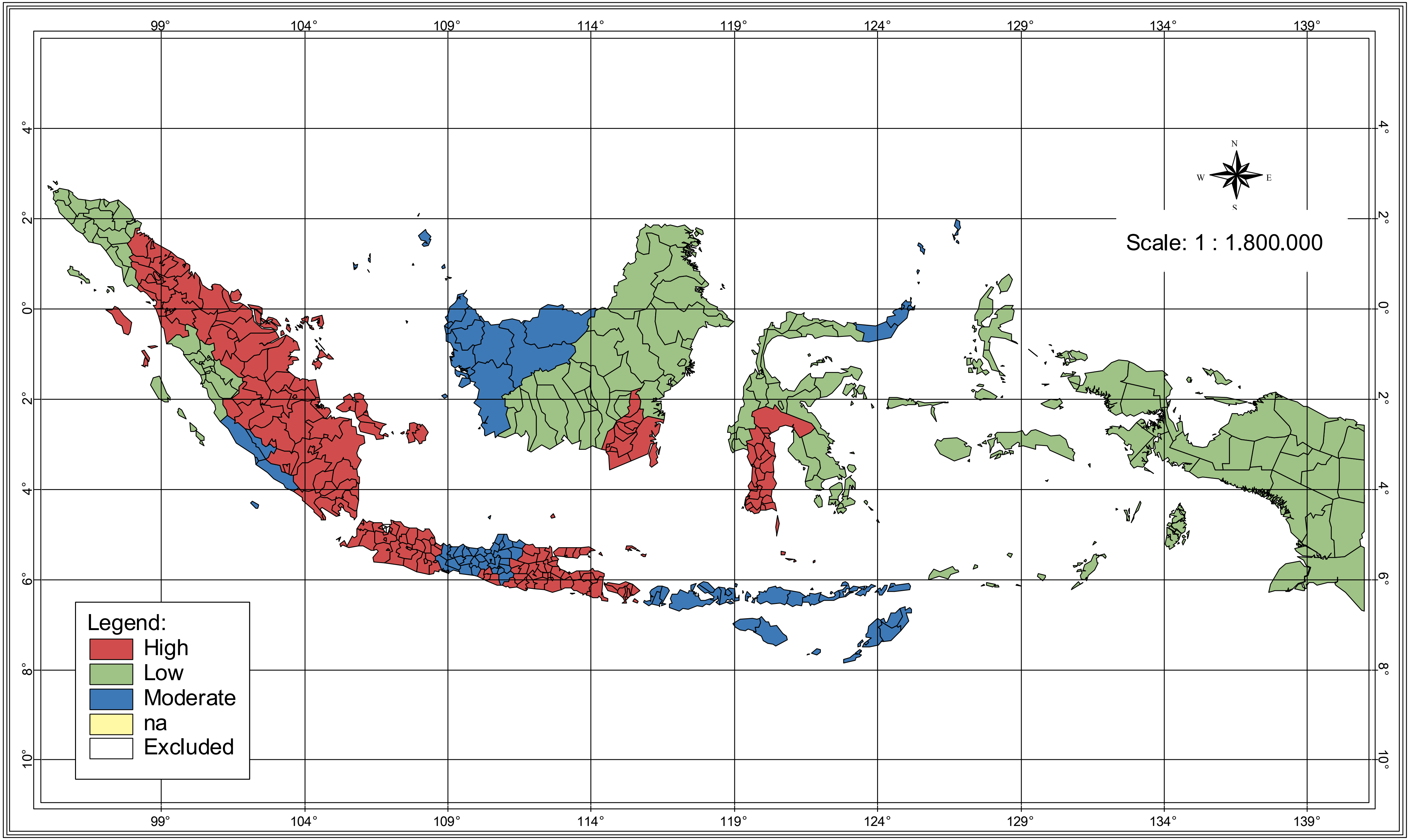
No. of Lags	**Calculated F-stat**	**Prob F>Critical**	**AIC**	**BIC**
Rural poverty rate (first Difference)				
0	230.23	0.0000	108.3846	113.5976
1*	27.04	0.0000	42.92784	47.10593
Forest coverage (first Difference)				
0	142.67	0.0000	505.7084	513.0363
1	**17.33**	**0.0000**	**446.0632**	**455.225**
2*	20.44	0.0000	350.5087	361.1444
3	4.10	0.0037	300.8227	312.4136

- Source: Author's own computation
- * Selected lag lengths are highlighted and the selection is done on the basis of the lowest information criteria (AIC) and the possibility of observation (more than lag 2 there is no observation).

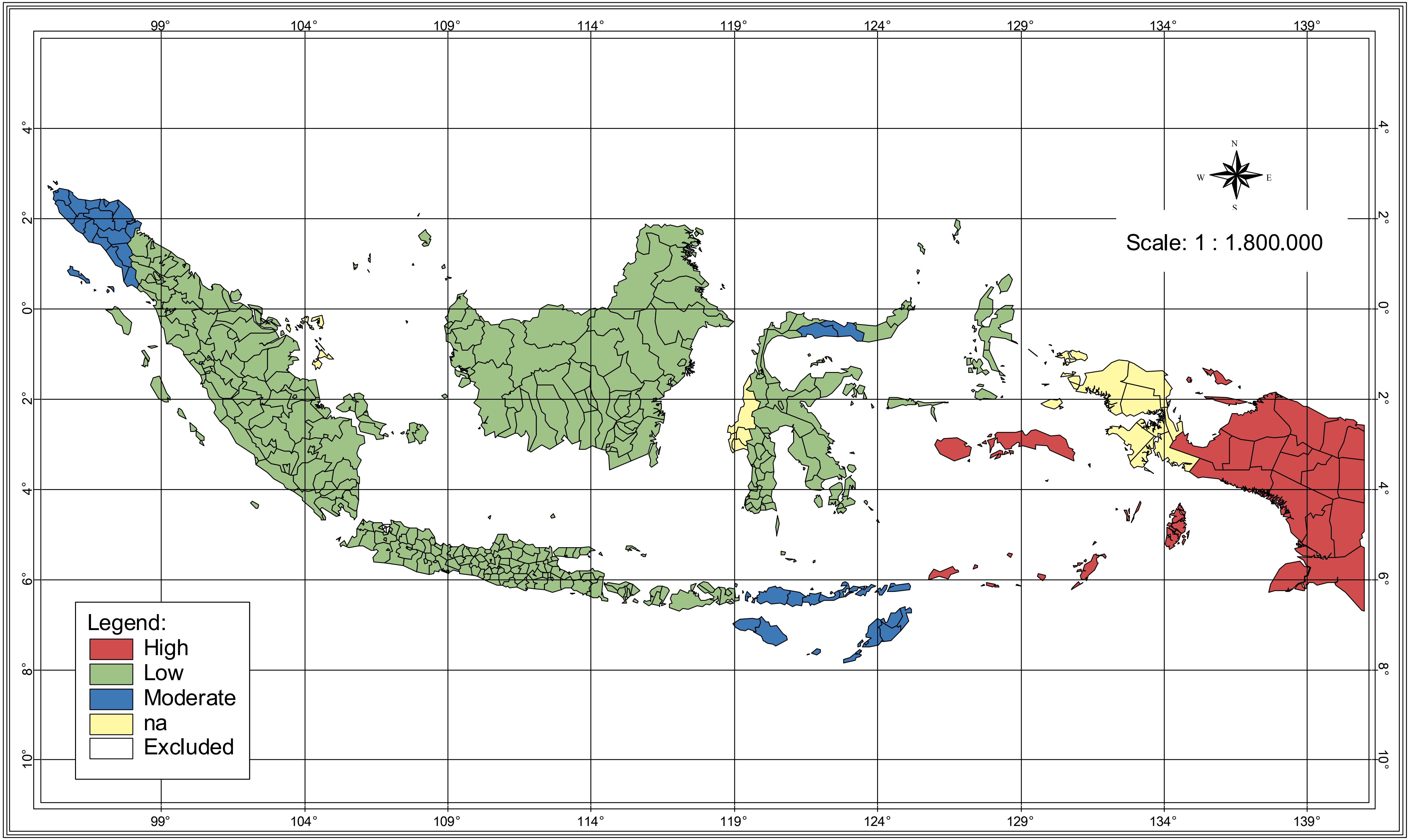
Environment Vulnerability 2002



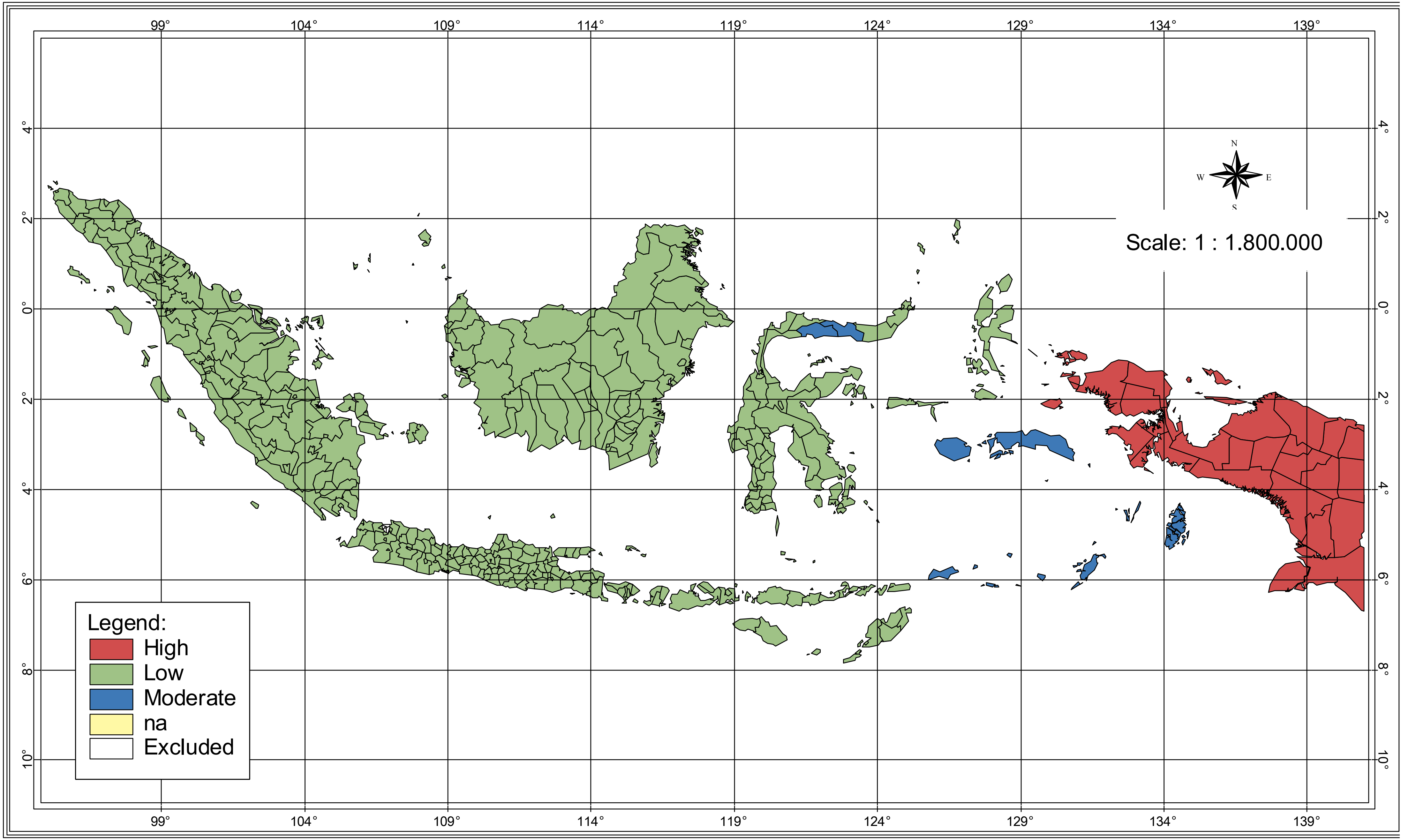
Environment Vulnerability 2010



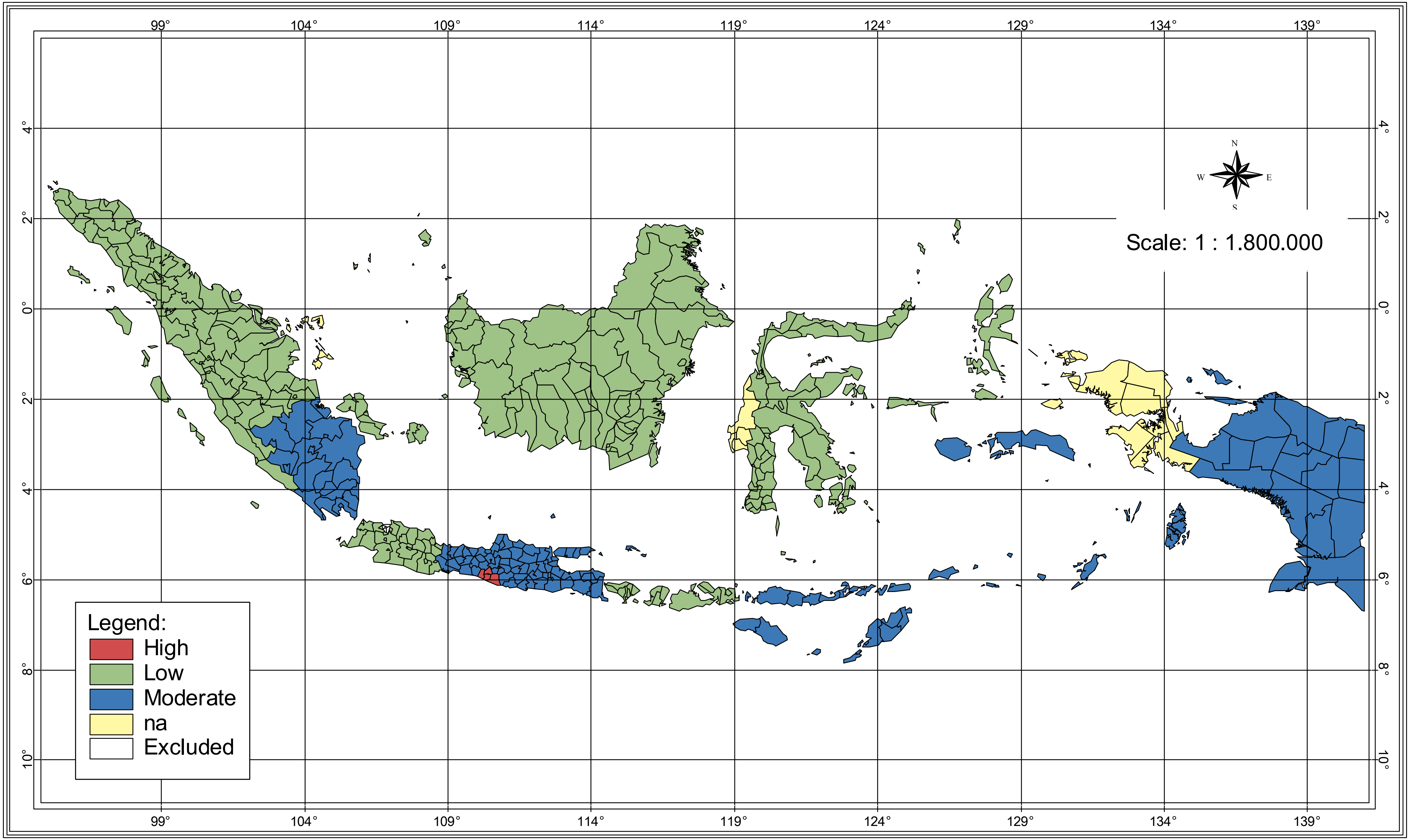
Poverty Vulnerability 2002



Poverty Vulnerability 2010



Poverty-Environment Vulnerability 2002



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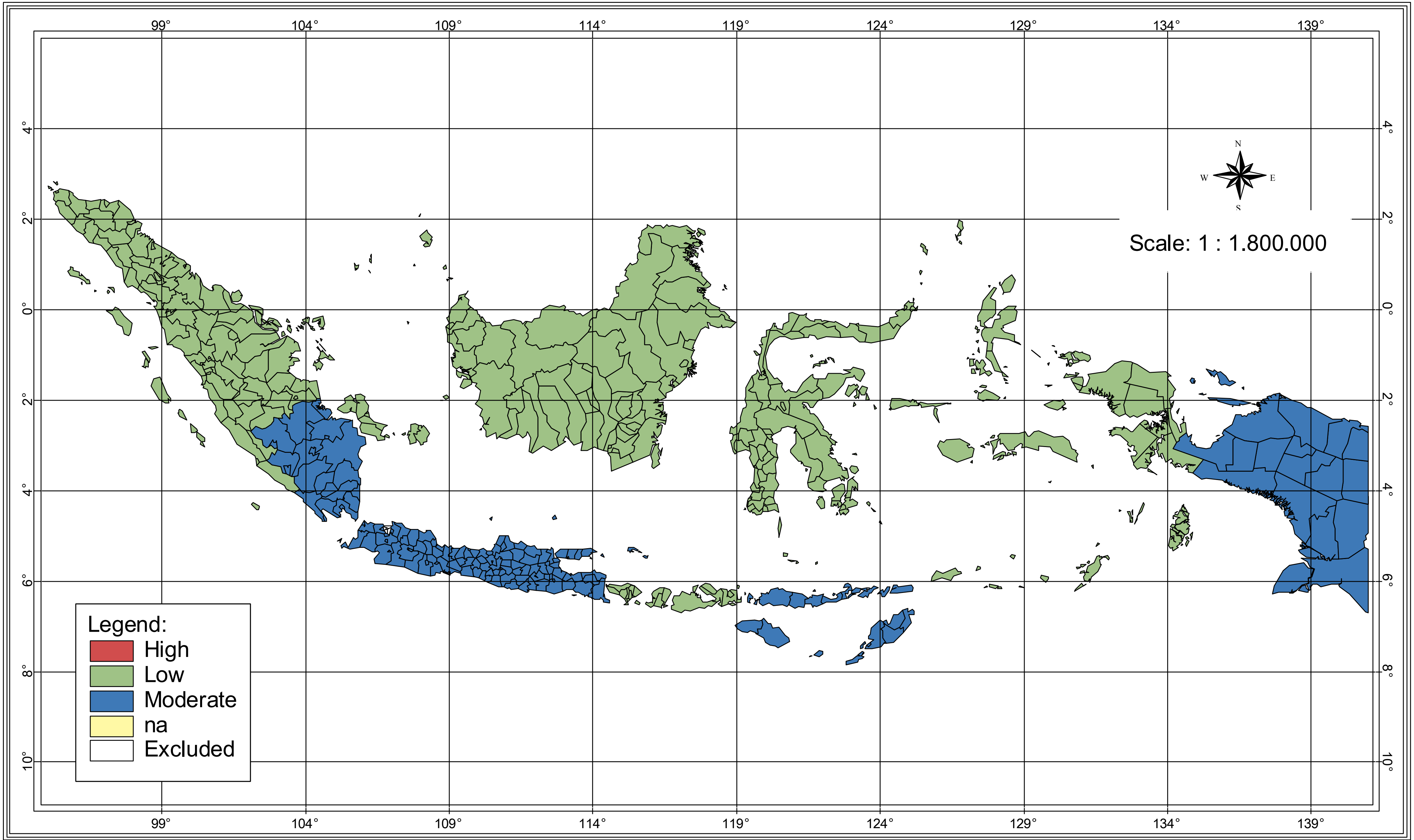
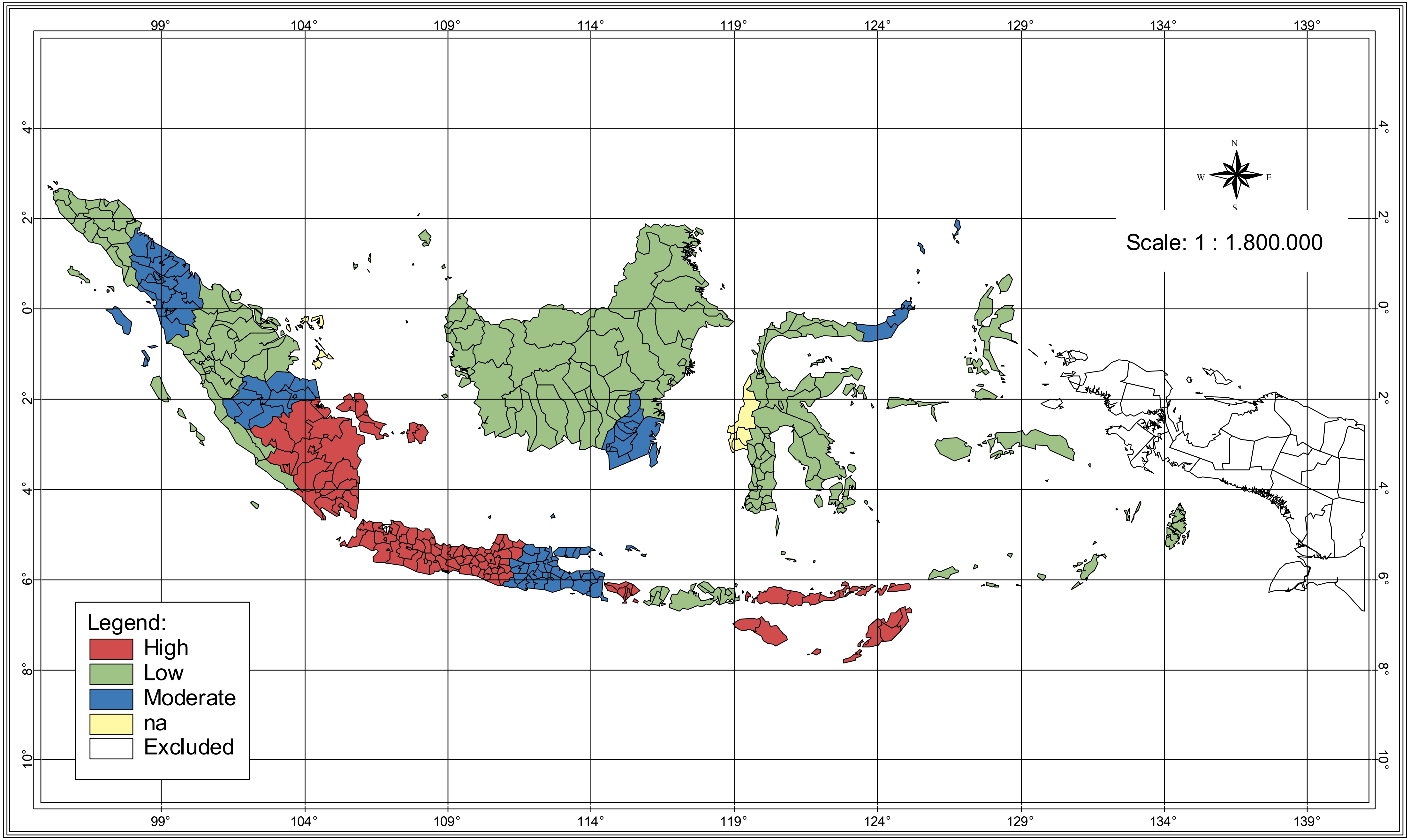


Environment Vulnerability 2002 Without Papua And West Papua



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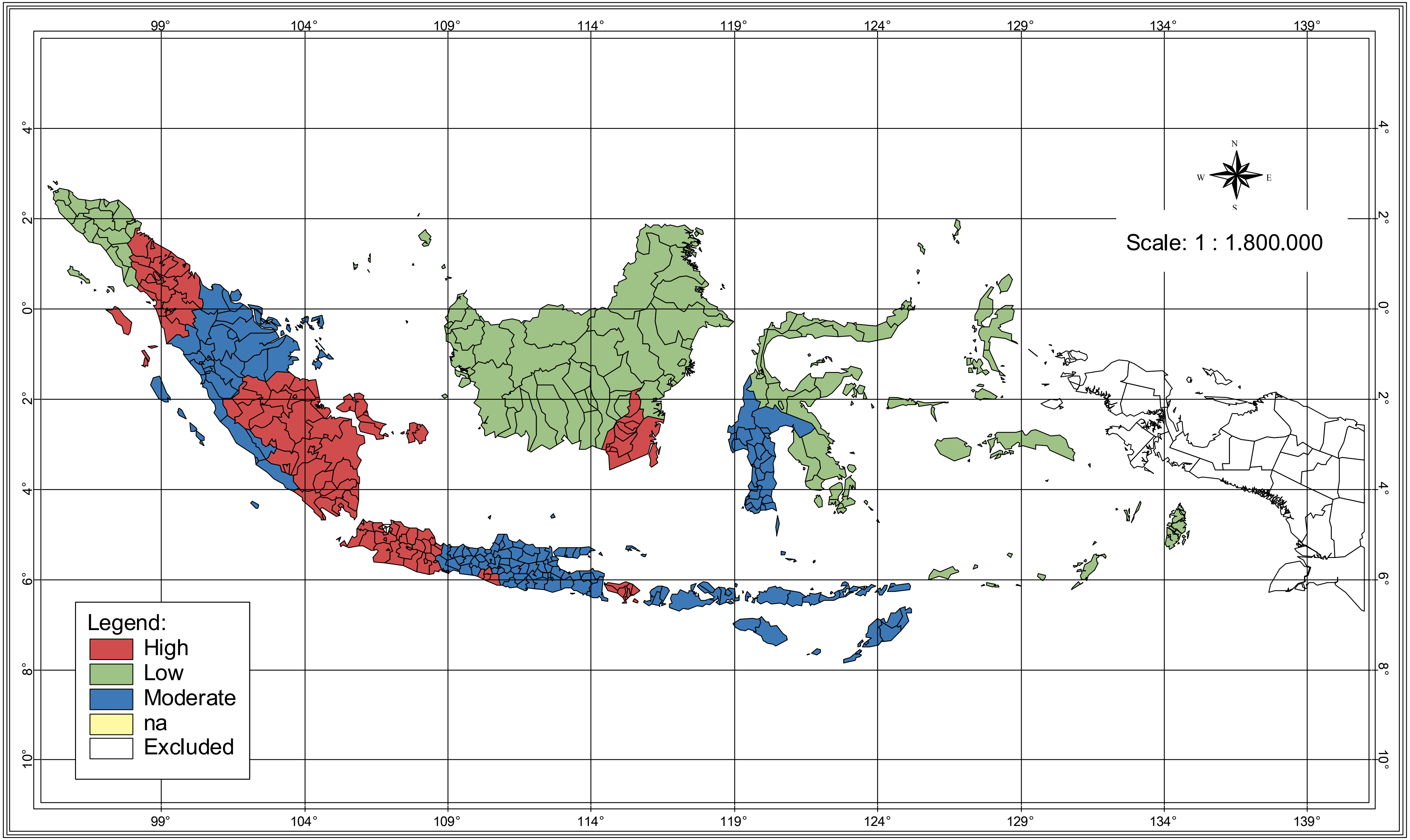
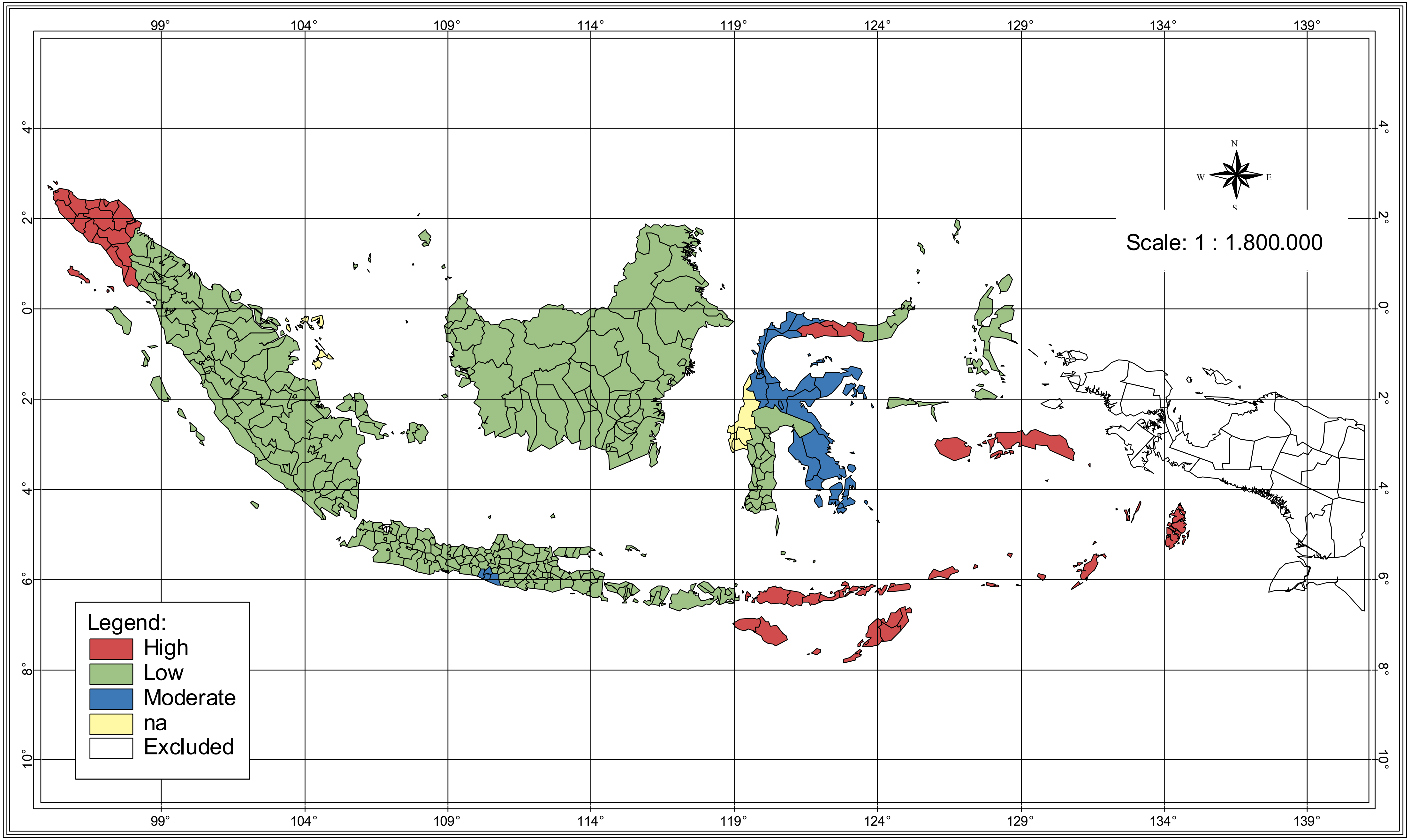


Poverty Vulnerability 2002 Without Papua And West Papua



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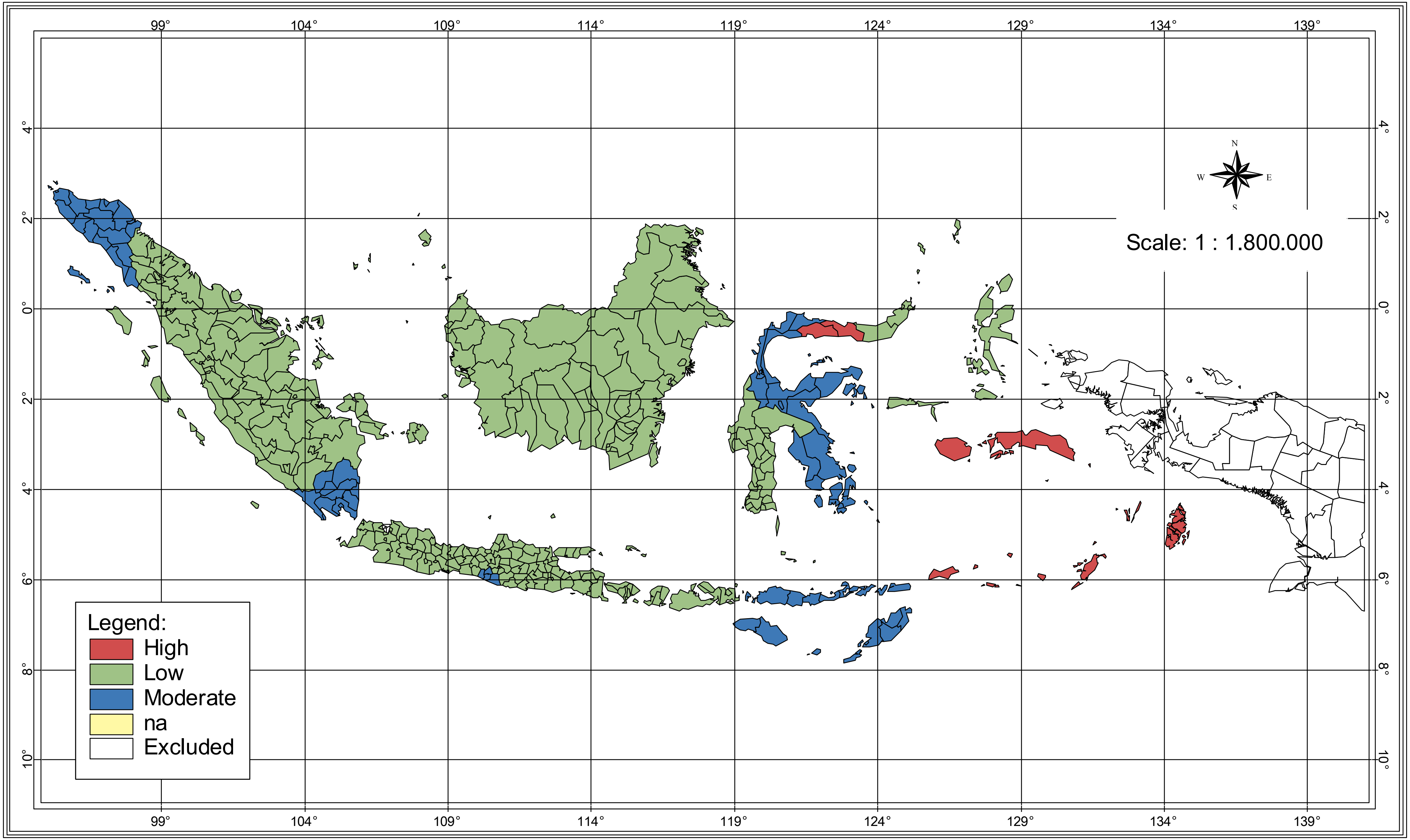
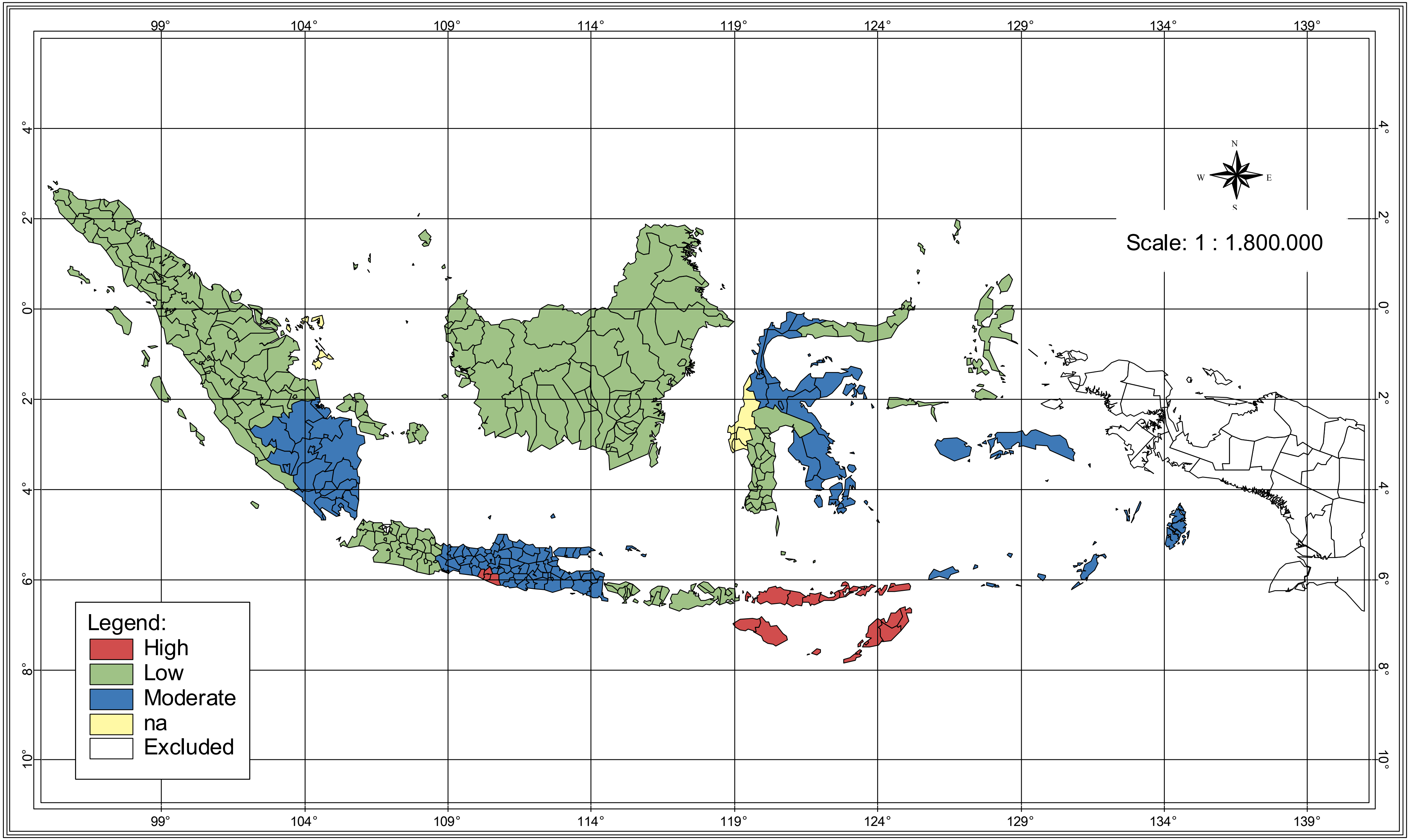


Poverty-Environment Vulnerability 2002 Without Papua And West Papua



Poverty-Environment Vulnerability 2010 Without Papua And West Papua