

## **Chapter 5**

### **Conclusion and Recommendation**

#### **5.1 Summary and Conclusion of the Study**

The environmental problem that have been emerging rapidly and severely all over the world, this forces us to act seriously on the protection and reduce natural sources degradation and depletion. Both production and consumption in the economy consume natural resources and utilize environment to survive and to grow as human need is infinity. This could be realized that the major root cause of environmental problem is from human-made rather than natural depreciation. The new concept of sustainable development has played the important role as focuses on the three main factors for development; economic, social, and environment. In term of Natural Resources and Environmental Economics, the key concept could be the attempt to seek for the optimal depletion rate under the technological progress that can develop or maintain the well human being, not only for the present generation but also for the future posterities who should have the right to get the good quality of natural resources sufficiently.

During this decade, air pollution appears to be one of the most critical environmental problems that need the cooperation from the world to solve this problem. The international cooperation is established legally such as (1) Earth Summit in Rio de Janeiro in 1992; this aims to stabilize greenhouse gas concentrations in the atmosphere. (2) The Kyoto Protocol in 1997; this aim at fighting global warming. Thailand has signed as the 89<sup>th</sup> member of the United Nations Framework Convention on Climate Change (UNFCCC) in non Annex countries-developing country group, which is not required to reduce emission levels unless developed countries supply enough funding and technology. However, we can sell emission credits to nations whose operators have difficulty meeting their emissions targets, and have our own policy to control the air pollutants. And recently, (3) the



Copenhagen Climate Conference 2009. Thus, a study of environment and growth should aim to be as comprehensive as possible.

In Thailand, the Pollution Control Department (PCD) has installed the air monitoring and meteorological stations in some main provinces, notably, there are two air monitoring stations in Chiang Mai. This province is located in the Northern Thailand and has become a world-class destination that attracts millions of local and international tourists each year, but this place has been facing with the air pollution problem critically during the dry season as we have seen in news. Therefore, this study focuses on air quality in Chiang Mai and PCD has provided the five major air pollution concentrations;  $PM_{10}$ ,  $O_3$ ,  $SO_2$ ,  $NO_2$ , and  $CO$ , which are measured and recorded in hourly basis for the last 15 years (1996-2010). Yupparaj Wittayalai School monitoring station is selected to represent the urban area and the hourly data is transformed into mean daily data for analysis. The study aims to conduct (1) the descriptive statistic analysis, (2) time series analysis and link them to Environmental Kuznets Curve hypothesis (3) forecasting the critical air pollutants by an econometric ARIMA modeling, and (4) recommend some economic instruments for air pollution control.

From descriptive statistic and time series analysis,  $PM_{10}$  has the highest standard deviation and variance. We may define the results into three groups according to the National Ambient Air Standard; (1) the peak concentrations of  $PM_{10}$  obviously exceed the standard, (2) the concentrations of  $O_3$ ,  $SO_2$  and  $CO$  are under the standard, (3) the concentration of  $NO_2$  is also under the standard but its peak level is closer the standard than  $O_3$ ,  $SO_2$ . However,  $PM_{10}$ ,  $O_3$ , and  $NO_2$  concentrations seem move similarly in term of seasonality.

$PM_{10}$  is treated as the most critical air pollutants in Chiang Mai Valley due to their maximum concentrations mostly exceed the standard of average in 24 hours (not exceed  $120 \mu\text{g}/\text{m}^3$ ). The top four of highest number of days with exceeding the concentration standard are in year 2004 (84 peak days), in 1997 (70 peak days), in 1996 (56 peak days), in 1998 and 2007 (38 peak days). Its high concentration periods are mostly in January to April each year, severely peak in March. Thus,  $PM_{10}$  concentrations will be preceded further in the ARIMA modeling and discussion in the Environmental Kuznets Curve (EKC) hypothesis.

ARIMA modeling is started from unit root test by Augmented Dickey-Fuller test (ADF-test), the  $PM_{10}$  concentration data is stationary at level or  $I(0)$ , ARMA model is then proceeded for forecasting the concentration for the next 365 days (May 2010 to April 2011) by fitting a model AR(1) AR(2) MA(1) MA(2) MA(3) MA(4) MA(5). The empirical results imply that  $PM_{10}$  concentration is associated with the concentrations from one day and two days ago, and associated with the residuals from one day to five days ago. The new data set of  $PM_{10}$  concentration from May 2010 until Feb 2011 (10 months) is obtained from PCD for comparison purpose, this study found the actual concentrations are (a) in +/- two standard deviation interval of the forecast; this implies that the model is fit very well, and (b) not exceed the standard.

To focus on the critical period of high  $PM_{10}$  concentration which causes the smoke problem that always occurs in February-March, this may due mainly to the meteorological condition which happen more frequency during cold and dry season; specifically, light winds, late night and early morning radiation inversions, which inhibit the vertical dispersion of pollutants.  $PM_{10}$  and smoke are generated more starting from December when harvest season begins and they require about four months before dispersed. The major man-made causes smoke problem in Northern area of Thailand could be from agricultural burning such as swidden burning or collecting some forest products, cattle burning, household burning. Other natural causes could be from forest fires and smoke trans-boundary from neighbouring provinces or countries such as Burma, Laos, or China. The potential shocks to raise burning activities by the local people could be from economic recession and political factor that force the people to work more in the farm and use more fires in their living as it is their traditional behavior, low cost, and provides fast action.

The EKC point of view for  $PM_{10}$ , the data is stationary from unit root test by Augmented Dickey-Fuller test, therefore, there is no trend in the data. This suggests that the  $PM_{10}$ 's situation of Chiang Mai may be in either these three cases; (i) the stable peak of the EKC (the inverted U-shaped curve), (ii) the stable peak or trough in the non-EKC (N-shaped or J-shaped curve), or (iii) the  $PM_{10}$ 's pattern has been constant for a long time. The limited data available for this study do not permit us to conclude. Consequently, Chiang Mai move from agricultural section to service section economically, this may contradict to the concept of stages of economic

development by Panayotou that define the industrial section at the stable peak of inverted U-shaped curve.

From the results mentioned above, the study can conclude that:

1.  $PM_{10}$  is most critical air pollutants in Chiang Mai Valley due to their maximum concentrations mostly exceed the standard. Although the rest four pollutants;  $O_3$ ,  $SO_2$ ,  $NO_2$ , and  $CO$ , are not exceed the standard but this does not imply that no policy must be concerned or taken care. On the other hand, this may be the result from the current policies which is effective and active properly. Thus, stop working on some concern policies may cause raising these pollutants level, notably,  $NO_2$  concentration is closer the standard line comparing with  $O_3$ ,  $SO_2$ , and  $CO$ .

2. The critical years of high  $PM_{10}$  are in 2004, 1997, 1996, 1998, 2007, 2000, and 1999 respectively. These years have more than 30 peak days of exceeding the standard.

3. The critical month of high  $PM_{10}$  is in March each year. This may due mainly to the meteorological condition during cold and dry season such as light winds and low radiation inversions, these inhibit the vertical dispersion of air pollutants.

4. The major man-made causes smoke problem in Northern area of Thailand could be from agricultural burning such as swidden burning, collecting some forest products, cattle burning, household burning. Other natural causes could be from forest fires and smoke trans-boundary.

5. The potential shocks to raise burning activities by the local people could be from economic recession that forces the people to work more in the farm and use more fires.

6. The  $PM_{10}$ 's situation of Chiang Mai has no trend over the past 14 years. In addition, stage of economy is moved from agricultural section to service section, these results could not be concluded in term of the EKC hypothesis.

7. The forecast of  $PM_{10}$  concentration for the next 365 days by fitting a model AR(1) AR(2) MA(1) MA(2) MA(3) MA(4) MA(5) fits very well with the data set under +/- two standard deviation interval and below the standard.

8. Potential shock to raise the smoke problem could be from economic recession that may effect to the labor transfer from non-agricultural to agricultural section and produce more smoke from unnecessary burning activities.

## 5.2 Policy Implication

The critical smoke problem or air pollution should be taken care by the authorities or policy makers more effectively and focus on these following policies recommendation seriously. From 4.5.3 which mentioned the major sources of PM<sub>10</sub> and smoke problem, recommendations are provided in order to reduce the pollution by sources. Since the air pollution is one of the externalities that the non-polluters could receive the impact from polluters, the local government should implement Polluter Pays Principle (PPP) which focuses on polluters who should pay for the damage. The PPP is generally enforced through Command and Control Approach (CAC: includes Technology-based and Performance-based) and the Market-based Approach (includes taxes, tradable permit, deposit-refund, and subsidies).

1. Agricultural burning: Government or local authorities may set a fine to the people who burn deliberately in the activities that the community agree not to do, especially during the critical period (December-March). In addition, the authorities should have the proper solutions to replace burning such as fermentation for making manure or organic fertilization, transferring the residuals into animal foods or into the efficient natural fuel for power station. Some solutions may need the technology and fund results in longer time to be implemented effectively, government should consider subsidies to organizations (private business or academic institutes) whom can develop the Go-green projects. Aim of future agricultural policy must ensure needed food supplies and reasonable incomes for farmers and to minimize the effects on the surrounding environment. Farmers also need to be rewarded for their countryside management roles, including preservation of wildlife, habitats, and endangered species and the maintenance of genitive resources, recreation, and leisure facilities. The use of clean sewage sludge from cities on crop land illustrates very clearly the interdependence of urban and rural areas in the recycling of resources. Secure land tenure should be used for reducing the externalities like open burning for regenerate corn's crop.

2. Household burning: Authorities may apply the deposit-refund schemes for the unused or solid waste such as batteries and promote more local traders or communities to buy the recycling materials such as plastics, papers, woods. Better

control on the destroy of household waste instead of burning such as landfill. To promote community participation with more campaigns and public relations about the harmfulness and impact of the air pollutions. To develop people awareness and promote the local authorities and community representatives to manage, annually measure and observe the local air condition by focus on the activities that generate the air pollution.

3. Cattle burning: Authorities may set a fine and a law for community fire control for the dry season, new method of getting new shoots with higher nutritive value should be developed and introduced to farmers.

4. Forest fires: This may occur naturally during the dry season or by unintentionally man-made spreading out to forest areas. Promoting community representatives in addition to the officers may reach to the burning area faster and for closer monitoring.

5. Smoke Trans-boundary: Abatement and recovery cost is a polluter's responsibility under the agreement in the region. Polluters (neighbouring provinces or countries) should pay the compensation. In contrast, the countries reserve forest (notably the developing countries) should get funding or subsidies from Annex I and II countries to reward on the positive externalities.

In term of theoretical sustainable development, moral and political force in addition to the economic development, social development, and environmental protection, would fulfill the theoretically sustainable development to be achieved.

### **5.3 Limitation of the Study and Recommendation for Further Study**

1. The air pollution concentrations have been measured and recorded officially by PCD since January 1996, the better time series analysis may require longer time series of data.

2. Air pollution data set may be divided as two half-year for deeper analysis if we assume there are the peak and low concentration period. For example, December–May could be declared as “dry” period and June–November could be declared as “wet” period.

3. Instead of air pollution concentration data, the emission level may be employed for analysis. However, the emission data is recorded for the nation, not for the specific regions or provinces.

4. More econometric models could be employed such as Seasonal ARIMAX, VARIMA, etc.

5. More related variables may be studied with the relation of air pollution such as data from meteorology, agriculture, tourism, transportation, energy consumption, etc.

6. In the EKC point of view, the measurement of environmental quality could be more international and should consider other dimensions of environment aspect such as water, soil, ore, or other natural resources.

7. Political factor could be studied deeper as a potential shock to the environmental degradation.