Usable Prospects of the Environmental Quality Indicators Model for Air and Water Pollutions Management in Chiang Mai Comprehensive Plans Boundary, Thailand

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Abstract

The building of new towns and city expansion are often associated with consequences against existing environment conditions. Including Chiang Mai municipal area, land use changes are dynamic process that linked to natural and human systems, economic pushing factors, upsurge land values and declining environmental quality. This study seeks to determine Chiang Mai municipal decision makers' comprehension, usability, and effectiveness of the determinative environmental quality indicators model through the landuse changes tendency and environmental quality indicators development for air and water pollutions monitoring in Chiang Mai comprehensive plans boundary from the year 2010 to 2030. The practices from this study were expected to enable the city's administrators to adopt the model as additional reference in decision making and contribute to more sustainable patterns of Chiang Mai municipal environmental monitoring and improvement plans. The finding outcome for this study is the Environmental Quality Indicators Model should be classified and implemented for short-term and long-term. For instance, the water quality and air quality indicators model should be used toward seasonal predictions and land use changes should be conjointly used as CMCP zoning and infrastructures management.

Keyword: Land Use Changes, Pollutions Management, Urban Expansion, Chiang Mai Municipal, Environmental Quality Indicators

Introduction

Chiang Mai city is growing at a rapid rate, creating extensive urban sprawls in different patterns (Sangawongse et al., 2012). A rapid urbanization has led to landuse changes into human settlements. Land use changes are a complex dynamic process that links between the human and natural systems and related to many environmental issues including social–ecological complex landscape, municipal air and water pollutions, municipal's air ventilation, and water drainage regimes alteration (Lebel, 2005; Lebel et al., 2008; Tan-kim-yong et al., 2005). After environmental quality indicators model was developed for air and water pollutions monitoring and implementation in Chiang Mai Comprehensive Plans Boundary (CMCP) (Sangawongse et al., 2011), the most immediate process to determine effectiveness of the model is to supply government executives and decision-makers with an indication of the environmental prediction trends as technical reference toward municipal action plan improvement and approval of short-term and long-term city's environment regulation.

This paper illustrates the investigation results of model effectiveness and usability through the extensive participations of actual demonstration and practice on the environmental indicators model database and analytical procedure by Chiang Mai Municipal and Royal irrigation department officers through the relationship between the air and water

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qualities as seasonal indicators with landuse changes as municipal comprehensive plan area improvement in both short-term and long-term periods.

Preceding Context

Relating to the findings from the previous study of landuse changes tendency and environmental quality indicators development for air and water pollutions monitoring in Chiang Mai comprehensive plans boundary from the year 2010 to 2030, the SLEUTH and environmental indicators models suggest that urban growth in CMCP has a tendency to increase over time while both air quality and water quality have tendency to decline (Sangawongse et al., 2012). Figure 1 is the prediction of urban growth for CMCP shown in red color of 5 years intervals from the year 2010 to 2030 (Sangawongse et al., 2011). Urban growth patterns are best captured by road influenced while the slope factor plays less role in shaping the urban landscape for CMCP. The impacts from urbanization and land conversions have deteriorated the environmental quality at a considerable rate. Sangawongse et al. suggested that there is a need for both government and the local residents in Chiang Mai municipal to closely monitor the impact of urbanization on land use changes on a regular basis. SLEUTH model provided reasonable result for mapping urbanized areas and land use changes from historic time (1973-2009) to the future time (2010-2030) for this study. The result of this project can be best applied to government and non-government agencies, including other agencies that are concerned with urban and environmental management and planning. It is expected that the outcome from this study can be used by the public, land use planners, policy makers, resource managers for various applications including municipal land use planning, policy making and decision making. Future research prospects of environmental quality indicators model for air and water pollutions management in Chiang Mai comprehensive plans boundary in both short-term and long-term, the water quality and air quality indicators model should be used toward seasonal predictions and land use changes should be conjointly used as CMCP zoning and infrastructures management. The additional remark from the previous study is only scientific approach of database and analytical procedures were developed. For future aspects, additional factors including national and local policies shifting, political influences, land values, global warming and climate changes should also be considered toward more effective environmental management.

Fig. 1 Prediction of Urban Growth for CMCP of 5 years intervals from the year 2010 to 2030 (Excerpted from Sangawongse et al., 2011)

Study area

The study area is located in the Monsoon Asian region of the Chiang Mai–Lamphun Valley, northern Thailand. Chiang Mai Comprehensive Plans Boundary (CMCP) is one of the

most developed regions in Thailand. CMCP has been undergoing a rapid urbanization within the past 20 years which are most likely become twin cities with Lamphun city in the near future (Sangawongse, 2006). Urbanization process plays a significant impact on environment, landuse changes, and policy play important roles in how urban regions developed. From Figure 2, the left side map represents boundaries of Chiang Mai provinces and the right side map represents the boundaries study area of CMCP which were designated by the Department of Public Works and City Planning (DPWCP) for land use zoning. The comprehensive plan is a guide for the city's future growth that includes the future land use plan, transportation plan, and recommended goals with objectives to carry out the plans. The CMCP area includes 7 administrative districts including Muang, Mae Rim, Sansai, Saraphi, Hangdong, Sankumphaeng and Doi Saket with total area of 408 square kilometers. The topography of the study area is characterized as a broad valley. Elevations in CMCP and its surroundings range from 300 m MSL to about 1,650 m MSL.

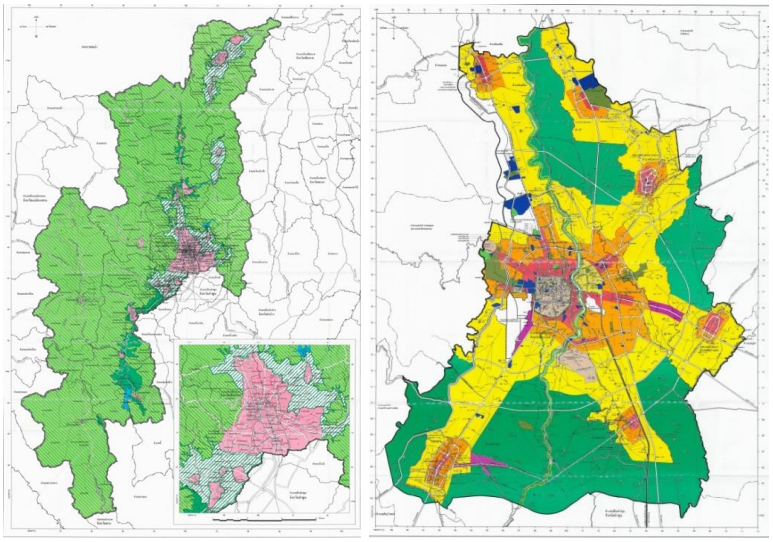
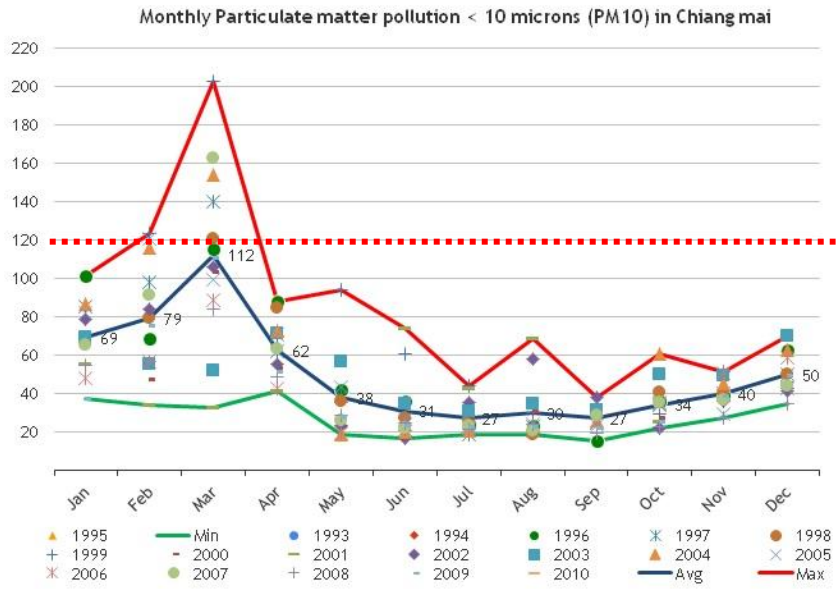


Fig. 2 Left: the study area of Chiang Mai Comprehensive Plans Boundary (the pink area) inside Chiang Mai province administrative boundary (the green area) and Right: the zoning details of CMCP

Methodology

This study utilized the results from the developed environmental quality indicator model including air quality, water quality, and landuse changes prediction trends (Sangawongse et al., 2011). The Particulate Matter with diameter less than 10µm (PM10) was selected as CMCP air quality database was obtained from the Thai Pollution Control Department. Total suspended solids (TSS) representing CMCP water quality database was obtained from the Royal irrigation department's hydrology and water management center for upper northern region. Both databases were arranged, and developed into air and water quality prediction trends using regression analytical procedure. In addition, the CMCP landuse changes prediction trend were obtained from the output of spatially open simulation models of urban growth patterns called the SLEUTH model (Clarke, K.C.et al., 2007). Both environmental quality databases and analytical procedure were presented to Chiang Mai Municipal and Royal irrigation department officers. The extensive participations of actual demonstration and practice on the model databases and analytical procedure were carried on. The environmental model outputs are illustrated in Figure 3, 4, and 5 which were categorized

into seasonal and non-seasonal trends. The monthly Particulate Matter PM10 trend form Figure 2 indicates seasonal CMCP air quality deteriorates at the beginning of dry season (December) and reached its peak in March before decreased by the end of April which correspond to other results from a previous study (Pengchai et al., 2009). Conversely, the monthly TSS trend form Figure 3 indicates seasonal CMCP water quality deteriorates at the beginning of rainy season (July) and reached its peak in August before decreased by the end of October. The conclusive prediction trends from Figure 4 illustrate prediction trends of environmental indicators from 2000 – 2030 which notify the long-term environmental quality decline for air, water, and landuse changes.



PM 10 Standard = less than 120 microns

Fig. 3 Monthly PM10 trend as seasonal air quality indicator

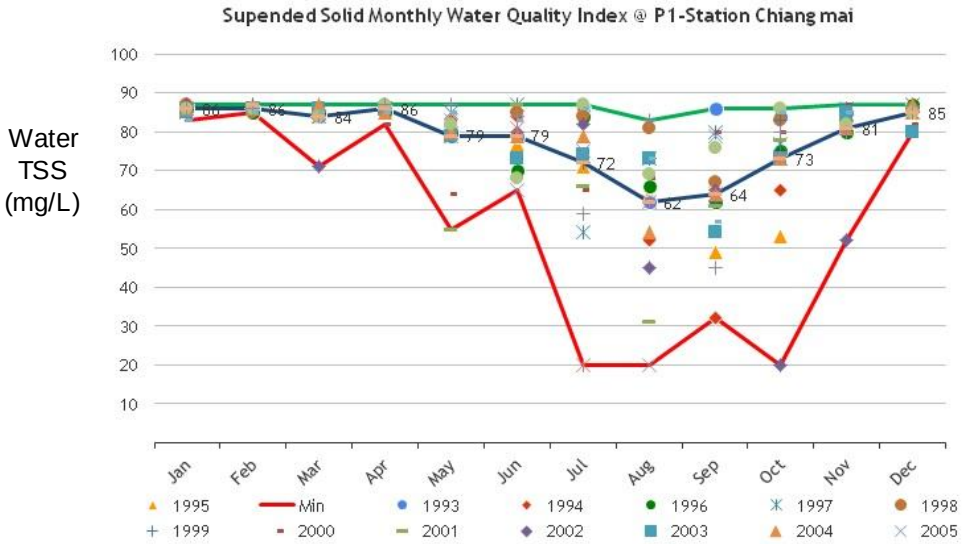


Fig. 4 Monthly TSS WQI trend as seasonal water quality indicator

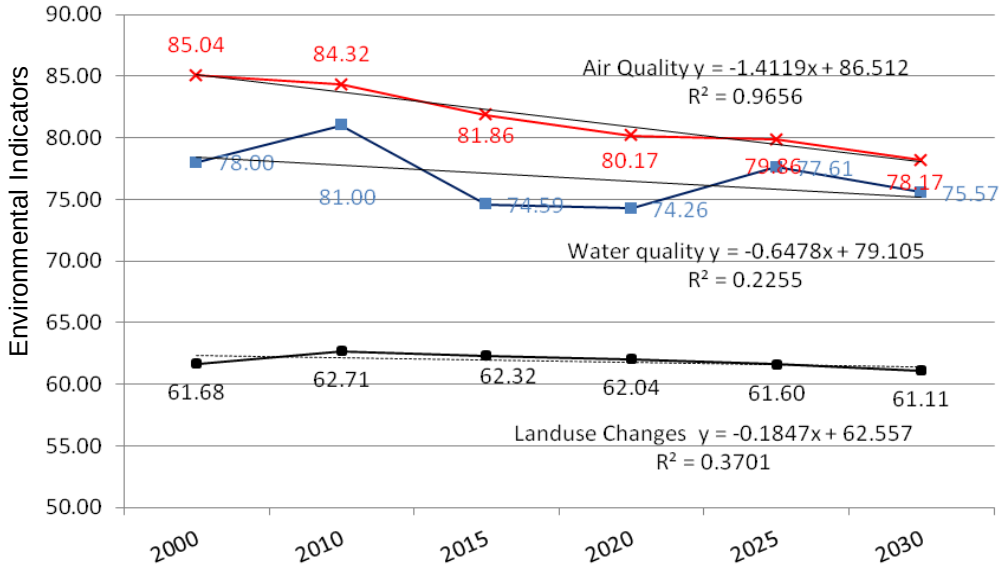


Fig. 5 Conclusive prediction trends of air, water, and landuse changes environmental indicators from 2000-2030

During the concluding phase of the environmental quality databases and analytical procedure implementation, the research databases and model usable and effectiveness prospects from 9 exclusive decision-makers were apprehended. The official decision-makers include 5 administrators of Chiang Mai municipal office and 4 administrators from Regional Irrigation Office 1, Chiang Mai. The Likert scale scoring and analysis were used for this research investigation (Likert and Rensis, 1932). Four key items about usability and effectiveness were inquired including (1) usability of environmental database, (2) usability and effectiveness of environmental indicators toward short-medium term implementation, (3) Usability and effectiveness of models' relationship for long-term action plan improvement, and (4) Usability and effectiveness of models' relationship as technical reference for government executives and decision makers toward municipal action plan improvement and approval of long-term city's environment regulation. The total of 28 sub-items was prepared for the research Likert scale scoring and analysis. Correspondingly, additional remarks from key officers were discussed to improve future research aspects.

Findings

This section illustrates the findings of Likert scale scoring results for the research model effectiveness and usability in short-term and long-term through the extensive participations of actual demonstration and practice on the environmental indicators model database and analytical procedure by 9 Chiang Mai Municipal and Royal irrigation department officers shown in the following Table 1. Regarding the four key items about usability and effectiveness result from Table 1, Chiang Mai Municipal and Royal irrigation department officers agreed on (1) usability of environmental database but less agreed on (2) usability and effectiveness of environmental indicators toward short-medium term implementation. The officers strongly agreed on (3) Usability and effectiveness of models' relationship for long-term action plan improvement and (4) Usability and effectiveness of models' relationship as technical reference for government executives and decision makers toward municipal action plan improvement and approval of long-term city's environment regulation.

On the subject of the key item (1), the usability of environmental databases of air

quality, water qualities and landuse changes for the environmental indicator model are appraised as agreed but remarked as less effective toward short-term plan than long-term plan for environmental quality monitoring. The officials are agreed that usability of air quality, water quality, and landuse changes output indicators for actual city planning for environmental strategic assessment are effective.

Accordingly, the key item (2) usability of environmental indicators toward short-medium term implementation of air quality, water quality, and landuse changes indicators are agreed to be usable and effective for prior incident preparations, during incident for environmental quality trend assessment, and environmental restoration plan after the incident.

The key item (3) the models' relationship between landuse changes and air quality for long-term action plan improvement concerning the expansions of landmark constructions that induce traffic congestion bottlenecks and increase air pollutions are agreed to be useable and effective. Likewise, the landuse changes and air quality relationship indicators are agreed to be usable and effective for CMCP air quality management as ventilation of Chiang Mai city becomes insufficient and air pollution cannot outflow from the area due to numbers of high-rise tower blocks in Chiang Mai municipal area are increased. Similarly, the long-term plans for Chiang Mai municipal environmental management toward better air quality including permanent ventilation devices installation, mount water spray on high-rise tower blocks, increase number of large fountains in Chiang Mai old city canal, and city's vertical green wall are agreed to be useable and effective.

The models' relationship between landuse changes and water quality for long-term action plan improvement are agreed to be usable and effective as CMCP long-term reference indicator for CMCP planning and follow-up monitoring regarding city's zoning and drainage management as the municipal urbanization replacing the city's natural floodplain and decrease city's overall drainage efficacy. Also, the relationship between landuse changes and water quality indicators are strongly agreed to be useable and effective reference for CMCP long-term design, irrigation structure management, and area zoning along the Ping River for the river's environment and stream flow improvement as the obsolete irrigation structures in the Ping River and river banks' encroachment in CMCP decrease the Ping River's drainage efficacy and increase water pollution retention in the river stream.

Finally, the key item (4) usability and effectiveness of models' relationship as technical reference for government executives and decision makers toward municipal action plan improvement and approval of long-term city's environment regulation were investigated. The relationship between landuse changes and air quality indicators is agreed to be an effective and usable reference for municipal's air quality improvement budget plan proposal including city's ventilation and long-term air pollution management. Likewise, the relationship between landuse changes and water quality indicators is strongly agreed to be effective and usable reference for municipal's water quality and drainage efficacy improvements budget plan proposal including city's runoff drainage and long-term water pollution management. Both models can also be used as long-term monitoring and follow up practices.

Table 1: The Likert scale scoring results of the research model effectiveness and usability

Usability and effectiveness of using database and analytical procedure from Chiang Mai Municipal and Royal irrigation department officers						
		Total:	9	Decision-makers		
Course #	Environmental Quality	Items about usability and effectiveness	Max. Likert Scale	Min. Likert Scale	**MODE**	MEAN
1	**Usability of environmental database**					
	Air Quality	1. Usability of air quality database for the environmental indicator model	5	3	**4**	4.11
		2. The use of Air quality database toward:				
		2.1 Short-term plan for environmental quality monitoring	4	2	**4**	3.78
		2.2 Long-term plan for environmental quality supervision	5	2	**5**	4.11
		3. The use of air quality indicator output for actual city planing for environmental strategic assessment	5	2	**5**	4.00
	Water Quality	1. Usability of water quality database for the environmental indicator model	5	3	**4**	4.22
		2. The use of Water qualitydatrabase toward:				
		2.1 Short-term plan for environmental quality monitoring	4	2	**4**	3.78
		2.2 Long-term plan for environmental quality supervision	5	2	**5**	4.11
		3. The use of water quality indicator output for actual city planing for environmental strategic assessment	5	2	**4**	4.00
	Landuse changes	1. Landuse changes database implementation for the environmental indicator model	5	3	**4**	4.11
		2. the use of Landuse changes model (SLEUTH) analytical procedure toward:				
		2.1 Short-term plan for environmental quality monitoring	4	2	**4**	3.67
		2.2 Long-term plan for environmental quality supervision	5	2	**5**	4.11
		3.The use of Landuse changes model output for actual city planing for environmental strategic assessment	5	2	**5**	4.11
2	**Usability and effectiveness of environmental indicators toward shot-medium term implementation**					
	Air Quality	1. The use of air quality prediction from the model for prior incident preparations	5	3	**4**	3.78
		2. The use of air quality prediction from the model during incident for air quality trend assessment	5	3	**4**	3.78
		3. The use of the air quality prediction from the model to plan for environmental restoration after the incident	5	3	**4**	3.78
	Water Quality	1. The use of water quality prediction from the model for prior incident preparations	5	3	**4**	3.78
		2. The use of water quality prediction from the model during incident for air quality trend assessment	5	3	**4**	3.89
		3. The use of the water quality prediction from the model to plan for environmental restoration after the incident	5	3	**5**	4.11
	Landuse changes	1. The use of landuse changes prediction from the model for prior incident preparations	5	3	**5**	4.11
		2. The use of landuse changes prediction from the model during incident for environmental quality trend assessment	5	3	**4**	4.00
		3. The use of landuse changes prediction from the model to plan for environmental restoration after the incident	5	3	**5**	4.00

Course #	Indicator (s)	Items about usability and effectiveness	Max. Likert Scale	Min. Likert Scale	**MODE**	MEAN
3	**Usability and effectiveness of models' relationship for long term action plan improvement**					
	Landuse Changes and Air Quality	1. Expansions of landmark constructions induce traffic congestion bottlenecks and increase air pollutions. The relationship between landuse changes and air quality indicators from the research model are useable for Chiang Mai municipal area planning and landmarks management	5	3	**4**	4.33
		2. Numbers of high-rise tower blocks in Chiang Mai municipal area are increased. The ventilation of Chiang Mai city becomes insufficient and air pollution cannot outflow from the area. The relationship between landuse changes and air quality indicators from the research model are usable for Chiang Mai municipal area management in terms of city's ventilation and effective air pollution outflow	5	4	**4**	4.44
		3. The long term plans for Chiang Mai municipal environmental management toward better air quality including permanent ventilation devices installation, mount water spray on high-rise tower blocks, increase number of large fountains in Chiang Mai old city canal, and city's vertical green wall should be implemented. The relationship between landuse changes and air quality indicators from the research model are usable as reference for Chiang Mai municipal planning and long term follow-up	5	4	**4**	4.33
	Landuse Changes and Water Quality	1. Chiang Mai municipal urbanization replaces the city's natural floodplain and decrease city's overall drainage efficacy. The relationship between landuse changes and water quality indicators from the research model are usable as reference for Chiang Mai municipal's long term planning and follow-up regarding city's zoning and drainage management	5	3	**4**	4.33
		2. The obsolete irrigation structures in the Ping River and river banks' encroachment in Chiang Mai municipal area decrease the Ping River's drainage efficacy and increase water pollution retention in the river stream. The relationship between landuse changes and water quality indicators from the research model are usable as reference for Chiang Mai municipal's long term design, irrigation structure managment, and area zoning along the Ping River for the river's environment and stream flow improvement	5	4	**5**	4.56
4	**Usability and effectiveness of models' relationship as technical reference for government executives and decision makers toward municipal action plan improvement and approval of long term city's environment regulation**					
	Landuse Changes and Air Quality	The relationship between landuse changes and air quality indicators from the research model is a usable reference for municipal's air quality improvement budget plan proposal including city's ventilation and long term air pollution management. The model can also be used as long term monitoring and follow up practices	5	4	**4**	4.33
	Landuse Changes and Water Quality	The relationship between landuse changes and water quality indicators from the research model is a usable reference for municipal's water quality and drainage efficacy improvements budget plan proposal including city's runoff drainage and long term water pollution management. The model can also be used as long term monitoring and follow up practices	5	4	**5**	4.67

Conclusions

The research prospects of environmental quality indicators model for air and water pollutions management in Chiang Mai comprehensive plans boundary are agreeable to be useable and effective including database and analytical procedure. For short-term and long-term, the water quality and air quality indicators model should be used toward seasonal predictions and land use changes should be conjointly used as CMCP zoning and infrastructures management. The additional remark from key officers toward this research is only scientific approach of database and analytical procedures were developed. For future aspects, additional factors including national and local policies shifting, political influences, land values, global warming and climate changes should also be considered toward more effective environmental management.

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