Carrying Capacity: An Approach to Local Spatial Planning in Indonesia

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Abstract: *A spatial planning act was introduced in Indonesia 1992 and renewed in 2008. It emphasised the planning role of decentralised authorities. The spatial planning act covers both spatial and environmental issues. It defines the concept of carrying capacity and includes definitions of supportive carrying capacity (SCC) and assimilative carrying capacity (ACC). The act mandates that the latter two must be taken into consideration in the local spatial plans.*
The present study aimed at developing a background for a national guideline for carrying capacity in Indonesian provinces and districts/cities. Four different sectors (water, food production, waste, and forests) were selected as core areas for decentralised spatial planning. Indicators for SCC and ACC were identified and assessed with regard to relevance and quantifiability. For each of the indicators selected, a legal threshold or guiding standard or governmental political objective exists. In most cases it was possible to select a set of indicators, including thresholds that are workable in a carrying capacity planning at the local administrative levels. Not all relevant sectors at the decentralized level were included. Indicators of SCC and ACC may increase the political focus on resources and environmental issues and may help to move local authorities towards a more holistic spatial planning approach. A carrying capacity approach could be an inspiration for local spatial planning in developing countries.

Key words: *Indonesia, decentralized spatial planning, carrying capacity, supportive and assimilative carrying capacity, indicators.*

1. Introduction

Spatial planning in Indonesia dates back to 1926 and the planning was oriented towards specific regulation of industrial installations and urban development. In 1992 the Indonesian Parliament passed the first Spatial Planning Act aimed at coordinating the management of natural resources and environmental problems. Spatial planning includes a plan-making process, plan implementation and development enforcement for national, provincial and local levels. The scope of the Act was "the planning of the structure and pattern of the use of space including land, water, air and other natural resources". Spatial planning defines the terms of areas and establishes protected areas, rural areas and urban areas. Administrative levels are the national level, the provincial level (number of provinces are 33) and the district/city levels (460 districts). The Indonesian spatial Planning Act stipulates hierarchical spatial planning including the national spatial plan, the provincial spatial plans and the district spatial plans. (Waddell 2002)

After Suharto's fall in 1998, the Spatial Planning Act of 1992 was considered to be no longer relevant in the new institutional settings. The Indonesian Parliament passed the new Spatial Planning Act in April 2007. It explicitly stipulates the authority and role of the provincial governments and of the district governments. In the previous Spatial Planning Act of 1992, the central government was responsible for coordinating spatial planning that covers two and more provinces and, the provincial government was responsible for making a spatial plan covering two or more districts. In the 2007 Act, spatial planning covering two or more provinces and drawing up the spatial plan became the authority of the respective provinces. The spatial plan is to be used as a coordination tool for the concerned provinces. The national government no longer has the authority to coordinate spatial planning covering two or more provinces. A similar rule applies to spatial planning covering two or more districts. As the previous one, the new spatial planning act emphasises that the concerned public have the rights to know the spatial plan, and participate in the plan-making process. (Rukmana 2008)

Indonesia has a long tradition of spatial planning, and since 2007 decentralised spatial planning has made it difficult for the national Ministry of Environment to govern what is going on in the huge country.

The concept of carrying capacity (CC) has been written into Indonesian spatial planning law mostly related to environmental issues. Carrying capacity is divided into supportive capacity (SC) and assimilative carrying capacity (AC). Supportive capacity means the capacity of the environment to support the lives of the people and other living organisms. Assimilative capacity (AC) is the capacity of the environment to absorb matters, energy and/or other components which come into the environment, either by themselves or through human intervention. The objectives of Indonesian spatial planning are an effective and efficient use of space, which is essential in sustainable environmental management, prevention of wasting space and prevention of degradation of spatial quality. Spatial planning is based on the characteristics of a given area, its carrying capacity and supported by relevant technology. The objective of spatial planning is to enhance the area´s compatibility, harmony and balance with its sub-system. (Purbo 2008)

The planning division in the Ministry of Environment does not have the power to enforce spatial planning at the decentralised level. From a national planning perspective, the planners want to develop a tool that can provide stronger links between resources and pollution by using the concept of carrying capacity. In the Indonesian context, a common guideline for carrying capacity planning might encourage the decentralised authorities to develop a planning procedure that will allow for coordinated actions among the decentralised authorities. If the provinces and districts use the same approach to spatial planning, the central authorities expect transparent governance.

2. Theoretical Considerations Concerning Carrying Capacity

In ecology, carrying capacity generally means the maximum number of individuals that can be supported in an environment without experiencing decreases in the ability to support future generations within the area (Kormondy 1996).

The concept is used to point out that there is a limit to the growth of biological populations, and an analogy can be made for human societies - there are a maximum number of humans that can be supported indefinitely in a given environment. In this case, carrying capacity is similar to the concept of sustainability especially when sustainability is divided into ecological, technical, socio-economic and cultural components (Schroll et al. 2006). Ecological and technical sustainability have the same features as carrying capacity concerning quantification and objectives. Ecological and technical sustainability have been measured by the Ecological Footprint. The basic idea is that every individual citizen, process, activity, and region has a material impact on the Earth. The Ecological Footprint analysis is based on the premise that all humans on Earth have an equal right to share natural resources and the environmental services (Friends of the Earth 1994).

Resource use can be converted to biological productive area that can function as a common yardstick or indicator. For a country such as the Netherlands with an area of 34000 km^2 and a human density of 440/km^2 the ecological productivity (supportive carrying capacity) of an area almost 15 times larger than the entire country is required. The footprint of the Netherlands shows that the country needs 15 times more land (Rees 1996).

Footprint calculations on resource use are often complicated. Fossil fuel can, for example, be converted to the area of forest needed to provide alternative fuels. Huge land areas will be needed to substitute fossil fuels. Instead the footprint developers argue that the fossil fuels resources are limited so there should be compensation of future generations by developing alternative fuels. The area needed for alternative fuels is included in future footprint accounts.

Objections against and critique of Ecological Footprint analysis are many. For example for burning of fossil fuel the Footprint component consists of estimating the land area needed to sequestrate the CO_2 emissions, i.e. "carbon sink". This is a questionable solution because CO_2 sequestrated by expanding forest areas is just one of several options to compensate for CO_2 emissions and a very land intensive option. Area is an inflexible one-dimensional parameter and the footprint analysis does not catch other options that could reduce CO_2 emissions. The Ecological Footprint does not make a distinction between sustainable and unsustainable land use and does not include the multiple use of land i.e. forestry farming. An evaluation concludes that the Ecological Footprint is not the comprehensive and transparent planning tool as often assumed. (Jeroen et al. 1999)

The carrying capacity for large areas includes many aspects and it is complicated to select appropriate parameters and indicators. An urban study performed in Seoul in Korea covering 40 km^2 used the carrying capacity approach. The study determined the components of urban carrying capacity to be environmental degradation and ecological quality, urban facilities, public perception, and institutional conditions. The main part of the study focuses on the quality of air and water, and seven primary factors are selected. For each factor an indicator is identified and it is an essential criterion for the selection of indicators that sufficient data are available to describe the trends. All the selected indicators are based on legal standards or political objectives (Oh et al. 2005).

Oh et al.'s study of carrying capacity developed a quantified method to measure how people can live on a particular area of land at particular levels of technology, consumption and pollution. Such an operational approach is prone to lacks and criticisms.

An operational carrying capacity study is open to criticism in at least three different ways. 1) The number of people who can sustain themselves on a given piece of land depends on their culture that determines both the needs and the ways of life. 2) Technology and consumption levels will be changing over time and then the objectives and demands for resources and environmental services will change. 3) A given land area's carrying capacity will depend largely on what happens outside its borders: upstream deforestation, greenhouse gas emissions, acid rain, global commodity price fluctuations. (Hildyard et al. 1993).

The two methods, Ecological Footprint analysis and Carrying Capacity are based on similar procedures such as defining an area, selecting resources and defining relevant indicators for quantification. For the indicators we assess that one indicator - area - as proposed in Ecological Footprint will be too complicated a measure and difficult to apply in a decentralized Indonesian context.

Indicators always simplify a complex reality and their significance goes beyond that obtained directly from the observed properties. Communication is a main indicator function that should enable or promote information exchange regarding the addressed issue. In relation to policy- making, environmental indicators are used for three major purposes:

1. To supply information on environmental problems, in order to enable policy-makers to value their seriousness.
2. To support policy development and priority setting, by identifying key factors that cause pressure on the environment.
3. To monitor the effects of policy responses.

(Smeets et al. 1999)

Indicators serve other basic functions than communication. They need to be quantified and measured without too many costs. Indicators have to be simple and standardized (EEA 2007).

For the present carrying capacity study the selection of indicators will be based on the Indonesian tradition for indicators. Indicators develop historically in a national context depending on many aspects such as technological level, natural environment and governance traditions. In the search for relevant indicators we gave priority to indicators reflecting national priority setting of thresholds, targets or objectives.

Indonesian legislation divides carrying capacity into two concepts: supportive carrying capacity (SCC) and assimilative carrying capacity (ACC). This approach to carrying capacity emphasizes the coherence between resource consumption and pollution. On the one hand there should be a sufficient supply of resources for the consumption of citizens and on the other hand the waste products and harmful impacts need to be kept within the assimilative capacity to avoid creating pollution problems. Pollution can be caused by toxic substances directly harming humans or ecosystems and in such cases a threshold can be set for the pollutants. Such a threshold is a concentration or dose based on scientific experiments and observations but economic assessments are also taken into consideration. For all pollutants, experiments show a range of concentrations can be found harmful to different creatures. Determining one concentration for a threshold is no warranty from harmful effects. Harmful effects can occur even if the threshold is observed. The point of our study is that the society in general can accept the consequences of a national standard. In some cases when the risks are perceived to be too high a pollutant will be forbidden. In the present study, a threshold is considered as a tolerable space for discharging a specific pollutant to the environment – the assimilative carrying capacity (ACC). The standards can be tentative or legally binding, but in both cases an ACC can be set. In other cases, political goals can be transformed to ACC indicators that can function under practical management circumstances. Use of the ACC concept means accepting a certain impact on humans and the environment. In this way ACC shows a situation established on uncertain and limited knowledge. In our view, observing thresholds of a selected indicator will in many cases bring improvement to the environment. Using the politically set thresholds as the basis for ACC means that the democratic decision process takes precedence over tradeoffs between environmental considerations and other societal considerations.

For some pollutants, the concept of assimilative carrying capacity is difficult to use even when there are thresholds set. An example can be the use of pesticides in agriculture. The purpose of all pesticides is to kill unwanted organisms in agricultural production systems. So by definition effective toxicity is an important characteristic of such chemicals. Well-documented risks are often present. Organisms might adapt to the pesticides and new often-stronger pesticides have to be applied. New chemicals introduced on the market are tested but they might convey unforeseen risks. Well-known chemicals like DDT and lindane caused damage to birds, other animals and perhaps humans. Many pesticides are persistent and accumulate in organisms' fat. Many harmful experiences related to pesticides should make us watchful and consider other prudent solutions to the problems. In the case of pesticides, we propose keeping within assimilative carrying capacity i.e. phase out pesticides and create a policy encouraging organic farming. It is a national choice to select a strategy for ACC but from our point of view it is a better alternative to allow the area of organic farming to represent an indicator of ACC for the agricultural sector.

3. Methods for the Carrying Capacity Study

The central Indonesian government wanted to develop principles and guidelines for enhancing the capacity of local authorities as regards decentralized spatial planning. The method is elaborated in cooperation with the Environmental Ministry and aims at determining carrying capacity in Indonesian provinces and districts/municipals. The development of the method is part of a major project on capacity building funded by DANIDA (Danish International Development Assistance). The DANIDA Environment Support Programme has funded a cross disciplinary team to analyse the concept of carrying capacity in order to prepare a spatial planning guideline that the central authorities - Deputy I, Ministry of Environment could provide to the provincial and district levels. The authors spent 1½ months working in the Ministry of Environment, Jakarta. (Ministry of Foreign Affairs 2007)

The purpose of the study was to review the concept of carrying capacity and to develop principles for applying the concept in decentralised spatial planning in Indonesia. With the given resources it was not possible to analyse all the relevant sectors using a carrying capacity approach so it was decided to identify criteria for selecting sectors and work with them as cases.

A number of spatial planning functions are legally binding for local government administrations. The following functions are listed in the law: sharing governmental functions between central government and local provincial government administration, and local Kabupaten (districts)/city government administrations. Activities like spatial structuring, environment, public works, land affairs, housing, cooperative and small and medium enterprises, food security and transportation are obligatory for local planning. Some activities are noted as optional such as agriculture, forestry, energy and mineral resources, large industry, transmigration affairs. (Government Regulation number 38/2007)

During the years 2002 to 2006, the Environmental Ministry in Indonesia published a yearly state of Environment report. Reading the reports gives an introduction to the environmental problems as they are perceived by the Government. Roughly it is possible to group the environmental problems into three categories. The first category includes a considerable number of environmental disasters like earthquakes, tsunamis, forest fires and haze, flooding, landslides and mud disasters. Another category covers environmental problems described in international conventions and how Indonesia copes with the international agreements. Examples are biodiversity and persistent organic pollutants (POP). The third category of problems is present in all the reports: water quantity and quality, air and atmosphere quality, land and forest degradation, coastal and marine degradation, energy supply, and municipal solid waste and hazardous waste. (State Ministry of Environment 2006)

The problems described and the indicators applied have not changed much over the years. A list of relevant sectors was compiled from legislation and environmental reports. The three criteria for selection of sectors are the following: 1) sectors where localized planning are relevant; 2) sectors where data are available locally; and 3) sectors that fit to the priority plans of the staff of the Environment Ministry. See Table 3.1.

The selection of sectors for carrying capacity assessment was undertaken as an iterative process involving the Deputy I staff and Indonesian scientists. They commented on draft papers and made proposals and arguments for relevant sectors and indicators. From the point of view of the Indonesian planners, the main priority sectors were water, food and waste.

In this paper, we present data water quantity and quality, food security and municipal solid waste because all criteria in Table 3.1 are observed. Furthermore we include land and forest degradation as a sector even though data are centralised and the ministerial staff were not very interested. The reason is that natural forests in upper watershed are important to water quality. Transportation is excluded because important decisions within this field are taken outside the jurisdiction of local authorities and the same applies to the remaining sectors. The concept of carrying capacity could also be used in relation to the mentioned sectors but providing data could be more complicated since other ministries have to be involved.

For the selected sectors - indicators with relevance for the Indonesian context and with a perspective for local spatial planning were selected after discus-

Table 3.1 *Selection of sectors*

Sectors	**Relevance of localized spatial planning**	**Data available locally**	**In favour of Ministry staff**
Water quantity and quality	+	+	+
Food security	+	+	+
Municipal solid waste	+	+	+
Land and forest degradation	+	-	-
Transportation	+	-	-
Air and atmosphere quality	-	-	-
Coastal and marine degradation	-	-	-
Energy supply	-	-	-
Hazardous waste	-	-	-

Note: + means positive assessment according to the above mentioned criteria, – negative assessment for different reasons.

sions with staff from the Environmental Ministry in Indonesia and by involving other persons in different institutions such as Ministry of Forestry (Deputy I 2008). The intention was to identify indicators covering the sectors, and for the indicators we looked for thresholds, targets, objectives or political goals. The challenge in the process is to identify indicators for the selected sectors. Staff from the Indonesian Environment Ministry and other Indonesian experts played an active role in the indicator selection process by providing information about available data and regulatory objectives and policies. Potential indicators should communicate important resources and significant environmental problems. Significant problems are such ones that impact the ecosystem by large amount of substances or hazardous effects or special concerns to local populations. Preferable indicators are used at the local level and new indicators should be easy to measure and understand. Thresholds and targets should be easy to establish and monitor.

The project would certainly have profited by visits to a number provinces and districts/cities. One (fieldtrip was the limit) was made during the project and it went to Yogyakarta, including a visit to the local environmental and planning authorities for waste and waste water planning. The Yogyakarta visit gave us an opportunity to discuss the feasibility of carrying capacity planning and to get an overview of the available statistical data (Yogyakarta 2007). Yogyakarta is a rather advanced city in Indonesia regarding available statistical data. As regards statistical data for other districts we rely on the information provided by the ministerial staff concerning data. The information is incorporated in the presentation of findings in section 4.

4. Findings from Carrying Capacity Planning for Selected Resources/Sectors

This section presents the findings from the study on carrying capacity for four sectors including supportive carrying capacity (SCC) and assimilative carrying capacity (ACC). For each sector, the SCC is divided into demand and supply and the indicators are directed against planning of resources. The pollution dimension - the ACC - consists of indicators and objectives considered feasible in spatial planning.

4.1. Carrying Capacity Planning of Water Quantity and Quality

Locally, many activities in a catchment area put pressure on the supply and quality of drinkable water. Carrying capacity implies, among other things, the establishment of conservation areas in the upper water catchment area where permanent vegetation can delay the water runoff. Protection of water resources against pollution requires a control of waste water discharges from households, industry and agriculture. Household consumption of water ranges from 60 – 150 litres per capita per day. Presently, carrying capacity could be set in this range. In 2006 the inhabitants of Yogyakarta used 113 litres per capita per day (Yogyakarta 2007). This is a relative low consumption compared to Seoul in Korea where it amounts to 310 litres per capita per day (Oh et al. 2005). In Indonesia, the expected future trend is that of higher water consumption per capita.

The available amount of groundwater and surface water resources per year with sufficient quality can be calculated and be set as the maximum baseline for carrying capacity. It should be stressed that available water in minimum situations should be the baseline for water carrying capacity in provinces and districts/cities. In some rural areas, reserving water for irrigation in agriculture is important. The need for irrigation should be taken into account when the carrying capacity for urban areas is calculated. Most of the drinking water needs or about 74% of drinking water for households in Indonesia are provided from ground water, and the remaining water is provided from river water and from rain water (MoE 2006).

The supportive carrying capacity (SCC) of water resources is a question of balancing available water resources and the demand for drinking water taking into consideration the possible negative impacts of the reduced water cycle on wild life. It could be argued that the suitable administrative management unit is on a higher level than the district for example the provincial level as in many cases a catchment area supply more than one district. On the resource side, feasible indicators have to be selected so that supportive carrying capacity can be calculated. Reliable indicators could be m^3 drinkable water and thresholds of unwanted substances. The SCC is available water of sufficient quality for a number of people, industries and irrigation or other purposes. Table 1a shows Indonesian demand for household water in urban and rural areas. Such a water supply statistic is available for Yogyakarta city (Yogyakarta 2007).

Assimilative carrying capacity (ACC) is a concept that states how much "activity" can be neutralized in nature without an unacceptable impact seen from the view of society. If households discharge waste water into a stream - organic matter will impact the stream by lowering the oxygen concentration. A low oxygen concentration can kill fish and invertebrates. The status of oxygen in running water is a common indicator of water quality and the impact can be measured as BOD (biological oxygen demand). BOD indicates the amount and degradability of organic matter. The lower the BOD, the lower oxygen concentration is measured in the stream.

In an unpolluted stream organic matter originates for example from leaves from trees falling into the stream and organic matter will degrade and be part of the natural metabolism. Depending on the type of streams and rivers more or less organic matter can be assimilated in the river without jeopardizing other uses of the river water.

In Indonesian legislation concerning BOD is used to divide streams and rivers into four classes of water quality. The four classes of BOD are respectively Class I = 2 mg O_2/litre, Class II = 3 mg O_2/litre, Class III = 6 mg O_2/litre, Class IV = 12 mg O_2/litre (Government Regulation no 82/2001). Concentrations under 2 mg O_2/litre represent the best water quality as it is assessed by the Indonesian authorities. Class I has a quality that allows it to be used for drinking purposes. Class II is acceptable for recreation and class III and IV can be used for irrigation. In cities with discharge of waste water, a much higher concentration of BOD can be measured and the authorities operate with a maximum threshold of 100 mg O_2/litre (MoE 2003). Other Indonesian BOD thresholds exist for comparison - hotel wastewater must observe a standard of 30 mg O_2/litre (MoE 1995). Such high concentrations of BOD will not be acceptable in natural water ecosystems. When pollution is above thresholds precautions have to be taken - for example by dilution or waste water treatment.

Our aim is to propose and argue for a general Indonesian assimilative carrying capacity for the indicator BOD. The general Indonesian classification system includes thresholds for acceptable water quality ranging from drinking water to irrigation. The assimilative carrying capacity threshold can be set to be between 2 and 12 mg O_2/litre. As a strict choice 2 mg O_2/litre can be selected. This means that ACC is the difference between 2 mg O_2/litre and the natural content of organic BOD in the water. A larger ACC can be selected if class IV is used as the acceptable threshold. When the acceptable threshold has been set, the amount of organic matter that the river can assimilate with no wastewater treatment can be calculated. The water flow in a specific river decides how many people can live in the catchment area and discharge untreated wastewater before the threshold of BOD 2 mg O_2/litre is exceeded. See Table 4.1a and 4.1b.

Data on SCC exists for water supply and wastewater treatment, and cubic metres of water are an assessable indicator at the local level. Trends in water consumption for households, irrigation and industries and fishponds are available for a local planning process (Yogyakarta 2007). For the surface water and pollution, the BOD is an important indicator, and thresholds are found from the Indonesian environmental regulation. For protection of groundwater no standards can be found even though the use of groundwater and wells are common in Indonesia. Standards for drinking water quality exist but these standards are not given by the Ministry of Environment. Much water consumption is related to agriculture and the planning for this purpose takes place in the Ministry of Agriculture. ACC can be determined for BOD as 2 mg O_2/litre. This ACC is a tool for planning where a new settlement depending on the water flow can be dimensioned so that the threshold will not be exceeded. COD is a less relevant indicator measuring difficult degradable organic material that is not so common from households. Establishing a threshold for nitrate in ground water does not make sense. For the carrying capacity planning the watershed management should be the unit of planning. In cases where several districts/cities are part of a watershed area, the provincial level will be the most relevant planning unit.

4.2. Carrying Capacity Planning on Food Production

Larger Indonesian cities import food from many districts. The pattern of food intake per capita differs depending on age, gender, occupation, income and other circumstances. Food per capita is decisive for calculating carrying capacity in the Indonesian districts. In Yogyakarta, the nutritional status for children under five years has been assessed for a number of years. In 2006, 11.3% were malnourished or undernourished (Yogyakarta 2007). On average, a person will have a calorie intake of 2,900

Tables 4.1a and 4.1b *Indicators for water resources. Supportive Carrying Capacity (SCC) and Assimilative Carrying Capacity (ACC) integrate a planning dimension and a pollution dimension*

4.1a **Supportive Carrying Capacity**	**Demand**	**Supply**
SCC on water consumption and supply in households	Water consumption is between 90 – 150 litres water per capita per day in urban areas and water consumption is 60 litres water per capita per day in rural areas (Purbo 2008a)	The minimum available amounts of water in m^3 per year for supply of cities and rural areas have to be estimated.
SCC indirectly [1)]	Thresholds for drinking water quality	Water treatment for iron and other unwanted substances
SCC indirectly [1)]	Thresholds for waste water effluents	Waste water treatment plants

[1)] Means that the available amount of water will change depending on the threshold set and water treatment used

4.1b **Assimilative Carrying Capacity**	**Indicator**	**Objectives**
ACC on BOD (biological oxygen demand)	Maximum BOD in water proposed as ACC can be 2 mg O_2/litre	A load of organic matter can be calculated for ACC
ACC on COD (chemical oxygen demand), turbidicity, coli	Thresholds exist and they can be used (Purbo 2008a)	Background load of different sources can be calculated and act as ACC
ACC on nitrate in ground water	The drinking water threshold for NO_3^--N is 0.06 mg/l (Indra 2008)	An AAC on nitrate in ground water cannot be established because the level cannot be controlled

kcal per day capita or 350 gram rice per day in cities and in rural areas higher calorie intake can be expected (Naik 2008).

For Indonesia the supply of rice can be used in the supportive carrying capacity calculations on food. Data for yearly rice production can be found for the districts and for the cities statistics on rice stock, supply and sale is available on a monthly basis (Yogyakarta 2007). Yearly average rice yield (three crops) was 4.8 tons rice per ha (Naik 2008). In Yogyakarta the average yield was 5.6 tons rice per ha per year (Yogyakarta 2007). If these data are used, the SCC for rice indicates that the yield from 1 hectare paddy rice field can sustain 44 Indonesian citizens per year. See Table 4.2a and 4.2b.

A detailed statistics on rice production allow for calculating SCC on a district level. Also data on the area of paddy fields and the trends of land use development can be found. Data for irrigation should be provided and used in water planning. For pesticides it is not acceptable to set an assimilative carrying capacity because these substances in principle are hazardous in agriculture and nature even though negative impacts for certain pesticides can diminish over time. ACC in this respect should, in our view, be encouraging organic farming. The area of organic farming will be a new indicator and it requires that the standard for organic farming should be legally established in Indonesia. Nutrients are part of natural systems. In principle nutrients are assimilative in nature but it is difficult in general to predict how much can be applied without creating negative impacts such as eutrophication or drinking water contamination. At district/city level there is no statistical information on the use of pesticides and fertilizers (Yogyakarta 2007).

4.3. Carrying Capacity Planning for Waste

Generally speaking municipal solid waste is disposed of in landfills and information is available at district level. On the basis of a ranking system including five categories of landfills and nine parameters such as drainage, leachate and gas handling, the Ministry of Environment concludes that landfills for cities in Indonesia are bad to very bad (MoE 2006). The local authorities control the solid waste landfills and the districts can improve their waste collection system by applying heavy equipment, drainage, gas handling, land zoning. Data on hazardous waste mainly from industries is available in the Ministry of Environment (MoE 2006). See Table 4.3a and 4.3b.

Waste collection is the responsibility of the local authorities and where it takes place statistical data are available. Composting solid waste can be a vital element of a waste planning system. Composting reduces the amount of solid household waste disposed of on landfill and allows recycling of nutrients. In that way composting is a feasible ACC indicator and it is easy to measure. A successful recycling of nutrient from waste requires separate handling of hazardous waste. Hazardous waste should be neutralized and kept in a controlled landfill or recovered or disposed of outside the biosphere or abandoned. Hazardous waste disposal should be planned at a higher level than the districts. Household solid waste contains plastic wrappings that can be separated at source and recycled before it ends in rivers, the built environment and in nature.

Tables 4.2a and 4.2b *Indicators for food production. Supportive Carrying Capacity (SCC) and Assimilative Carrying Capacity (ACC) integrate a planning dimension and a pollution dimension*

4.2a **Supportive Carrying Capacity**	**Demand**	**Supply**
SCC on food	The calorie intake per capita per day in cities is on average 2,900 kcal/day (Naik 2008)	Rice yield per ha are known in districts (Yogyakarta 2007)

4.2b **Assimilative Carrying Capacity**	**Indicator**	**Objectives**
ACC on pesticides	Area of organic farming	Increase in area of organic farming
ACC on nutrient levels and balance	Nitrogen input/output ratio	Avoid overload of nitrogen

***Tables 4.3a and 4.3b** Indicators for municipal waste. Supportive Carrying Capacity (SCC) and Assimilative Carrying Capacity (ACC) integrate a planning dimension and a pollution dimension*

4.3a **Supportive Carrying Capacity**	**Demand**	**Supply**
SCC on waste collection	A clean and healthy environment	Waste collection systems are available in urban areas as collection points and landfills
SCC on hazardous waste	Separation of hazardous waste from municipal waste	Infectious waste from hospitals and hazardous waste like batteries should be treated separately from municipal solid waste

4.3b **Assimilative Carrying Capacity**	**Indicator**	**Objectives**
ACC on organic waste	Organic waste collected for composting	Composted material can be used as fertilizers if not contaminated by heavy metals or other hazardous substances
ACC on plastic	Tons plastic collected for recycling	All plastic should be collected and recycled

4.4. Carrying Capacity Planning of Forestry

Forests in Indonesia are divided in three types; conservation forests, protected forests and production forests. Illegal logging is a problem that has been reduced over recent years (Jæger 2008). In 2003 illegal logging was estimated to be 49 % and in 2006 it was reduced to 6% of the total logging (or 11.3 million m^3) (MoE 2007). In 2004 74 million hectares of forested land was classified as critical land which is forested land damaged by illegal logging, land clearing, mining purposes, fire and land conversion to plantations or agriculture. According to the zoning law in Indonesia developing of the critical land will

***Tables 4.4a and 4.4b** Indicators for wood production. Supportive Carrying Capacity (SCC) and Assimilative Carrying Capacity (ACC) integrate a planning dimension and a pollution dimension*

4.4a **Supportive Carrying Capacity**	**Demand**	**Supply**
SCC on wood	Domestic wood consumption in m^3 per capita per year. Exported wood in m^3 per year	Production forest
SCC indirectly	Yearly cutting quota for each province (MoE 2006)	Securing a stable wood supply

4.4b **Assimilative Carrying Capacity**	**Indicator**	**Objectives**
ACC on certification	Coverage of international certificates	Area covered by certified forestry
ACC and clean development mechanism (CDM) Forest area defined as critical land is potential land for projects within CDM	Forest area defined as critical land is potential land for projects within CDM	Tons CO_2 captured by forest handled within the rules of CDM

still be the responsibility of the Ministry of Forests (MoE 2006). See Table 4.4a and 4.4b.

Local wood consumption in m^3 per capita per year can be calculated and an SCC can be found for districts. Different kinds of certification have been applied to foster sustainable production forest management in Indonesia (MoE 2006). Certificates of sustainable forestry ensure that the forest is managed in such a way that clear cutting is not allowed. An ACC can be the area of certificated forests. Critical land can be converted to forest and the CDM system for CO_2 capture in forests might be applied for funding. Hectare critical land converted to forest is an ACC indicator.

Forests play an important role in providing drinking water especially upstream forests serve as protecting rivers from erosion and reduced water quality. Upstream dense forests areas are a planning target set by the districts and provinces but the target is difficult to reach. The legal demand is that forested areas must account for at least 30 % of the rivers' upstream areas (Rukmana 2008).

5. Conclusion

A basis for establishing carrying capacity has been developed for Indonesian provinces and districts/cities. It integrates resource planning and pollution planning in what we will call a carrying capacity spatial planning. According to the new Indonesian Spatial Planning Act a division in supportive carrying capacity and assimilative carrying capacity has to be made.

Supportive means the capacity of the environment to support people and other living organisms without harming future possibilities. Supportive carrying capacity planning covers what traditionally is deemed spatial planning. Pollution planning is covered by the assimilative approach. Assimilative carrying capacity is the ability to absorb matters and energy, which enter the environment without harming future possibilities of assimilation. In principle the resource use and pollution from an activity will be planned in the same process.

Indicators play an important role in carrying capacity planning. The indicators proposed can all be quantified, measured without sophisticated equipment, are easy to understand for administrators and local people and most of them are based on Indonesian objectives or political goals. As we see it, the proposed indicators can be applied by the provinces and the districts/municipalities as the data are already registered or can rather easily be provided and used as new indicators. Thresholds or political goals can serve as objectives. Further studies must be done to demonstrate whether or not all the districts can cope with the proposed carrying capacity planning but for Yogyakarta city it will be possible.

Some of the sectors (water and hazardous waste) need to be planned on a higher level than the districts. Water and hazardous waste could be planned at a provincial level. Energy resources not included in this study will need a national level planning.

Assimilative carrying capacity is complicated when it comes to defining indicators and setting thresholds and objectives. The indicators are chosen so they represent the important impacts related to a sector and the thresholds and political targets set for the sector. The assimilative part of carrying capacity is defined as the space to a legal threshold or guiding standards or political objective because these regulations have been articulated and launched in the Indonesian society. The politically established threshold expresses society's acceptance of use the assimilative ability of the natural ecosystem. For water it can be calculated how much assimilative carrying capacity can be used in planning practice. If the assimilative threshold of the indicator is exceeded mitigating measures must be incorporated in local spatial planning.

A weakness of the system is that thresholds and politically set objectives might not be strong enough to protect the nature and the environmental services. As a number of the Indonesian thresholds are taken from international recommendations the use and observance of such thresholds will be an environmental achievement in spatial planning.

A guideline for carrying capacity planning in Indonesian provinces and districts/municipalities can be accomplished for the four sectors. Indonesian experts have to expand on indicators, legal standards and political goals. In this study, four sectors have been analysed but we are convinced that other sectors can be developed following the same principles where national indicators and objectives leave a space for resource consumption and use of natural assimilation. In principle, the concept of carrying capacity encourages comprehensive local planning where resources like forests can be protected if their presence is beneficial to other resources like water quality.

Post Scriptum

In 2009 a carrying capacity guideline was enacted as a Ministerial Regulation by the Minister of Environment. It only deals with supportive capacity, and it consists of three parts:

1. Supply/demand of water in an area (water availability versus water demand).
2. Supply/demand of land in an area (simplified bio capacity/ ecological footprint principles).
3. Land capability approach - especially for protected areas and prime agricultural lands.

(Purbo 2010)

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