# Studies on Economic and Environmental Efficiency of Makassar City in Indonesia: AHP and CGE Modeling Approaches

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June, 2014

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# Abstract

Economic action and the environment affect one another's performance. Economic and environmental changes affect the welfare of society. Environmentalists and economists agree that indifference to the environment has caused the depletion of natural resources and environmental degradation. The underlying reason for the underestimation of assets is that not all environmental goods and services are included in the economic analysis of programs and policies. Environmental problems must be prevented, and the damage caused by economic development must be reduced. Economic development can be sustainable, or it can be compatible with the viability of natural systems. Economic and environmental development requires an analytical instrument to evaluate the most appropriate economic and environmental strategies.

Indonesia is a developing country that is expanding in every economic sector. However, Indonesia's government has scarce financial resources that must be allocated efficiently for development. $CO_2$ emissions and the decline of natural resources due to of human economic activity intended to improve the standard of life cause green-house-gases (GHG) that can alter the natural balance and the climate-change process.

This study addresses economics and the environment using a methodology to analyze the efficiency of resource allocation. Resource allocation is a trade-off that can be resolved by the price mechanism. This study attempts to achieve the best possible result for the environment while assuming the lowest possible loss of economic objectives.

This study examines the following issues: (1) the provision of public goods such as road construction on the Maros-Watampone Road; and (2) the urban economics of Makassar City. This study applies an analytic hierarchy process (AHP) to design efficiency with respect to selecting the best type of road construction in a conservation area. We refer to Wicksell's theory (1977) that in a perfectly competitive market, a voting system returns the same results as a price mechanism for decision-making. However, the public cannot explain references to the public goods. Economists have proposed a public participation method (AHP) concept by substituting the criterion entity for the person entity. Therefore, efficiency is a feasible environmental solution where the value of one criterion can only be achieved by degrading the value of at least one other criterion. The evaluation method to determine the efficiency of economic resources provides an integrated framework to evaluate an investment from a public perspective. AHP enumerates all of a particular project's direct costs and benefits to society assigns monetary values, discounts them to a net present value and adds them into a single number to evaluate the project.

The Maros-Watampone Road crosses a critical geometric conservation area that is a barrier to development. Previous studies recommend the three following alternative constructions: an elevated bridge, a cut and fill, or tunnel system. The government invited community members to participate in selecting the best construction in their region. Using the AHP, the results showed that the criterion of benefits (0.300) is the major factor in determining construction priority; the second major factor is environmental criteria (0.224). Construction costs (0.081)

and maintenance criteria (0.054) had no significant effect. An elevated bridge is the most suitable type of construction (0.528), followed by cut and fill (0.248) and the tunnel system (0.223). The higher contributions of benefit and environmental criteria indicate that community preferences cannot be measured using the price system. In addition to relatively large energy consumption, construction activity simultaneously created $CO_2$ emissions. Thus, an estimation of $CO_2$ emissions indicates that elevated bridge construction has lower emissions (1.31 Ton$CO_2$/km) than tunnel construction (1.79 Ton$CO_2$/km). The decision-making process showed that the public has begun to pay attention to quality of life and the environmental effect caused by development activity. We evaluated the efficiency of economic resources based on the following analyses: benefit-cost, net present value (NPV), and internal rate of return (IRR). Evaluating the investment feasibility of the best construction shows that the public's decision is the correct choice to support the government's decision. Public participation in economic development is one way to achieve efficiency in economic resources.

The second research method uses a computable general equilibrium (CGE) model that adds environmental objectives to urban economic objectives in Makassar City. After calibrating the model to Makassar's economy and choosing the reduction of $CO_2$ emissions as the environmental objective, we can establish efficient economic development. Accordingly, we can estimate how much economic growth must be sacrificed for each environmental goal. It is also possible to determine in which direction the mixed policy should be reformulated

to obtain combinations of efficient economic activity and minimal environmental impact.

The model examines the impact of the carbon tax based on the 2006 input-output (I-O) table for Makassar City and estimates a social accounting matrix (SAM) table for the same year. In CGE models, general equilibrium is achieved through the price mechanism. The model assumes a static economy with no time-related elements. Twenty-eight industrial sectors and two production factors, labor and capital are used in this study. A model economy contains a single representative household that establishes its consumption to maximize its utility subject to its budget constraint. The utility function used is the constant elasticity of substitution (CES), in which the household maximizes utility subject to a budget constraint. Every industry uses an intermediate input to produce one commodity for each sector without a commodity by-product. Firms are assumed to maximize their profits by managing inputs and outputs subject to their production technology. Firms are assumed to be perfectly competitive and to have achieved equilibrium in 2006 through flexible price adjustments.

The carbon tax policy is assessed using two simulations. In the first simulation, a carbon tax is imposed on all industries without household transfer, and in the second simulation, the tax revenue is transferred to households. The government transfers funds to households in an amount equal to its carbon tax revenue. In theory, the implementation of a carbon tax will reduce $CO_2$ emissions and increase government revenues. Furthermore, household welfare will increase, output prices will increase and households will reduce their consumption.

The results of all simulations of the CGE model indicated that a carbon tax is able to reduce the volume of $CO_2$ emissions by eight percent. In general, output prices and production volumes declined. The demand for capital tended to be fixed, and labor demand declined after tax revenues were transferred to the representative household. Household consumption declined following the imposition of carbon taxes but increased in response to the transfer of carbon tax revenues. Therefore, household welfare increased after receiving transfers from the government.

It is crucial to effectively manage efforts to reduce $CO_2$ emissions. Managing emissions involves not only production-side efforts related to environmentally-friendly technology but also prevention of a decline in commodity consumption preferences.

This research describes two approaches to allocate resources efficiently and can be used to choose policy that favors both the environment and human wellbeing without sacrificing economic development.