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Fair fund distribution for a municipal incinerator using GIS-based fuzzy analytic hierarchy process

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Abstract

Burning municipal solid waste (MSW) can generate energy and reduce the waste volume, which delivers benefits to society through resources conservation. But current practices by society are not sustainable because the associated environmental impacts of waste incineration on urbanized regions have been a long-standing concern in local communities. Public reluctance with regard to accepting the incinerators as typical utilities often results in an intensive debate concerning how much welfare is lost for those residents living in the vicinity of those incinerators. As the measure of welfare change with respect to environmental quality constraints nearby these incinerators remains critical, new arguments related to how to allocate the fair fund among affected communities became a focal point in environmental management. Given the fact that most County fair fund rules allow a great deal of flexibility for redistribution, little is known about what type of methodology may be a good fit to determine the distribution of such a fair fund under uncertainty. This paper purports to demonstrate a system-based approach that helps any fair fund distribution, which is made with respect to residents' possible claim for fair damages due to the installation of a new incinerator. Holding a case study using integrated geographic information system (GIS) and fuzzy analytic hierarchy process (FAHP) for finding out the most appropriate distribution strategy between two neighboring towns in Taipei County, Taiwan demonstrates the application potential. Participants in determining the use of a fair fund also follow a highly democratic procedure where all stakeholders involved eventually express a high level of satisfaction with the results facilitating the final decision making process. It ensures that plans for the distribution of such a fair fund were carefully thought out and justified with a multi-faceted nature that covers political, socio-economic, technical, environmental, public health, and industrial aspects.

Keywords: Environmental impact assessment; Fuzzy analytic hierarchy process; Geographic information system; Environmental economics; Environmental management; Fair fund

1. Introduction

Solid waste management is in crisis in many of the world's largest urban areas as economic development continuously attracts more populations to cities. This has led to ever increasing quantities of municipal solid waste while space for landfill disposal decreases. Some of the municipal managers are looking to the development of municipal incinerators around the periphery of their cities as a first solution in many countries. This is especially true in those countries with relatively smaller land resources available, such as Japan and some of the Organization of Economic Cooperation and Development (OECD) countries in Europe, such as Germany. Siting and construction of a municipal incinerator requires the acquisition of modern waste-to-energy technology and good day-to-day operation in order to minimize possible environmental impacts based on an environmental impact assessment (EIA) or environmental impact statement (EIS). Yet sometimes level of attention to environmental issues/problems during project concept and planning stage is low and environmental problems

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are often identified at later stage of the project life cycle, such as operational stage. Consequently, public reluctance with regard to accepting the incinerators as typical utilities often results in an intensive debate concerning how much welfare is possibly lost for those residents living in the vicinity of an incinerator because of long-term exposure to those environmental impacts during operation.

Given the fact that incineration project developers armed with rosy financial forecasts based on the anticipated energy recovery profit and the waste disposal fees can be found in all corners of the globe, the concern of inherent environmental impacts and hence welfare loss in local communities could lead to an operational burden for such day-to-day operation. Conflicts between local residents and owners/operators of municipal incinerators were reported very often as headline news in some developing countries during the 1990s (Chang and Chang, 2000). These problems may include but are not limited to air pollution, traffic congestion and noise impacts due to waste shipping and operation, wastewater treatment and disposal, ash disposal, etc. The disturbance during the decision making process of fair fund distribution could be that the environmental impacts caused by an incineration project might decay heterogeneously along the distance away from the facility resulting in a complexity that the marginal benefits and/or costs may vary spatially. To endorse a real ''economically optimum'' fees collection system, the use of policy instruments in environmental management regime brings up some basic ideas of allocation theory that involves relocation of waste disposal fees as part of a fair fund. In other words, the provision of waste treatment and disposal utility for a specific region may encounter higher environmental impacts and such a fair fund should be redirected to balance the external costs for these communities in that region located in the vicinity of an incineration site. Flexible combination of these policy instruments can further be initiated and employed to set up possible integrated remedies for environmental externalities via an institutional arrangement. Although work of using policy instruments is underway to remedy the short- and long-term environmental externalities, little has been done to develop decision making processes that tie these issues and relationships within the context of environmental management together at the societal level. More stringent regulatory requirements plus policy concern are fueling the need for innovative decision analysis to cost-effectively remediate stressed communities in confrontation with welfare losses due to regional pollution prevention and control actions. This brings up a new research need in the nexus of environmental management, environmental economics, and environmental policy.

The question of challenge is how to build upon the rules or policies, which are the most appropriate or at least the most acceptable ones for stakeholders. Given that stakeholders' participation cannot guarantee a smooth allocation there is a need for developing a lucid procedure designed for a screening level assessment providing scientific clues to support the fair fund distribution. It at least empowers the decision makers to set up corresponding rules via a technocratic process. This paper purports to develop such a methodology facilitating the essential decision making process under uncertainty while fairness with respect to reciprocity and social exchange in waste management service district is particularly taken in to account in a self-management process within those affected communities. Factors of concerns resembling more a retrospective environmental impact assessment (EIA) after the plant has been built include major environmental concerns in the context of a Multiple Criteria Decision Making (MCDM) process under uncertainty. With the aid of a geographic information system (GIS) platform combined with the fuzzy analytic hierarchy process (FAHP), rules of fair fund distribution developed thereafter may allow a great deal of flexibility for municipal managers to pursue a long-term operation of incineration projects without having irrational blockade by local communities. The following sections aim to provide a high level advice on approaches that are basically scientifically self-supporting, environmentally responsible, and socially acceptable.

2. Study area and problem identification

Taipei County Government governs the largest administrative areas in Taiwan having three modern large-scale incinerators commissioned in the mid- and late-1990s. Before having these three incinerators in place, municipal soil waste (MSW) had ever been accumulated on the street without collection for months due to running out of landfill space. The area had really been poised at the brink of social chaos all this time over the waste disposal issues. The incinerator of concern in this study is located in a valley that is close to the administrative boundary between Shu-Lin (Towns A hereafter) and In-Kou (Town B hereafter) in Taipei County, northern Taiwan. The service district of Shu-Lin incinerator, which has been in operation by a private subcontractor since 1995, covers seven townships located in Southwest Taipei County. With an area of 4.5 ha surrounded by small mountains, the Shu-Lin waste-to-energy (WTE) plant is equipped with a modern mass burn waterwall furnace that permits the routine processing of 1350 tonnes waste per day using three treatment trains. From the storage pit the waste is fed into the furnace where the combustion takes place on a Martin-type movable mechanical grate system. Within each treatment train, the generated flue gases in the furnace pass through the first furnace and are cooled down at the outlet of secondary furnace by the installations of a superheater, a boiler tube bank, an economizer, and a heat exchanger that is installed in the thermal cycle for the preheating of auxiliary combustion air. The flue gases are eventually led through a well-designed air pollution control system, consisting of a conventional cyclone associated with dry sorbent injection followed by a fabric filter to absorb heavy metals, such as mercury, and toxic gases, such as dioxins/furans. A well-designed monofill including a leachate treatment plant was constructed in parallel with the Shu-Lin WTE facility as a permanent facility for the disposal of wastewater sludge and incineration ash.

The equity concerns with regard to this event could be that neighborhoods of an incineration site do bear a disproportionate share of environmental impacts of waste collection, traffic