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Developing the Soci-economic Urban Sustainable Planning Strategies Based on the Smart and Inclusive Growth Principles*

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Abstract: In 2010, EU adopted a new growth strategy which includes three growth priorities, i.e., (1) Smart Growth, (2) Sustainable Growth and (3) Inclusive Growth to be reached by 2020. Over the years, studies have been developed to examine issues in urban growth, or more recently inclusive growth. These types of issues are complex and require inter-disciplinary analysis. As the sustainable development has become a major trend in the urban planning, the concept of growth management principle has also become an important element in urban sustainability. The aim of this research is to investigate an urban development strategy for smart, sustainable and inclusive growth which will more likely include ambitious objectives addressing soci-economic, environmental and governmental issues. The inclusive growth management efforts that arise in response to problems associated with urban sprawl exhibit a great variety of forms. Moreover, inclusive growth management regimes need to be expanded to address the full range of economically productive land uses found in urban areas, including industrial land, which has been overlooked by smart and inclusive growth advocates (usually to the detriment of their communities).

Key words: soci-economic urban planning; EU 2020 strategy; inclusive growth principles; sustainable planning; multi-objective optimization model; urban land development and management

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1. Introduction

As exclusive planning and decision-making has resulted in the situation of social exclusion, there have been world-wide efforts to introduce inclusive measures in urban planning. A bunch of measures have been introduced to improve the inclusiveness in both outcomes and processes of urban planning. First, the outcome-oriented policies aim at improving the quality of lives for the excluded, including inclusionary zoning and public housing. Next, the process-oriented policies aim at enhancing the participation in the planning processes, as in the case of communicative or collaborated planning. UN-Habitat launched in 1999 a campaign on urban governance to promote a vision of the "inclusive city", focused mainly on promoting good governance and decision-making processes (UNCHS, 2000).

A planning decision making of the urban land development and management has to satisfy many different

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stakeholders' demands simultaneously which is actually a process considering multi-objectives. The multi-objective aspects arise when considering the conflicting interests of the various stakeholders involved in land development decisions: the government planner, the environmentalist, the conservationist, and the land developer. The purpose of this study is to construct a multi-objective optimization model for the application to the urban land planning problems in Taiwan. As the fact that the scale of urban have extended broader and broader due to many reasons since middle 20th century, more and more natural resource has been consumed by the city. With the aim to solve these problems caused by urban sprawl, the concept called "Smart Growth" principles has been brought up in this research. This research study is planning to construct a multi-objective optimization model based on the previous research studies, and the concepts of Smart and Inclusive Growth principles will be utilized as the important criteria in constructing the framework of the model. The resulting optimization problems are convex, quadratic mixed integer programs that are NP-complete. We report numerical results with this model for New Taipei City, Taiwan, and present them using a geographic information system (GIS).

Urban sprawl and the congestion of cities have become the inevitable development trend in the process of economic growth. At the early stage of urban development, there lacks of design and control strategy towards urban planning and development. The pursuit of better living conditions and the auto-oriented development have led to urban sprawl and leapfrog developments. These developments include: single-houses are built in suburban areas; the consumption of massive land and high infrastructure maintenance cost are disproportionate to the population; and more worse, sprawl has caused environmental and energy consumption issues that have never been happened before. Currently, in land development, there is a move towards intelligent stewardship of natural resources to avoid urban sprawl. Such development schemes are often called Smart and Inclusive Growth. However, this term can be a bit nebulous since what constitutes Smart and Inclusive Growth for one stakeholder (or stakeholder group) may not necessarily be intelligent management of resources for another stakeholder. One needs to consider land development with all stakeholders' interests taken into account (Gabriel, Faria & Moglen, 2006).

The concept of Smart and Inclusive Growth concentrates growth in compact walkable urban centers to avoid sprawl. It thus emphasizes on compact, transit-oriented, walkable, bicycle-friendly land use, including neighborhood schools, complete streets, and mixed-use development with a range of housing choices. The movement leads to the formation of the Smart and Inclusive Growth Network. The Network is formed by the U.S. Environmental Protection Agency and joined with over 40 organizations from a diverse array of interests. It is operated by a group of people including planning experts, architects, private development companies, and local citizens.

To model explicit tradeoffs between stakeholders in this zero-sum setting, as presented in Mogle, Gabriel and Faria (2003), we consider four main classes of stakeholders: The government planner, the environmentalist, the conservationist, and the land developer. The resulting mathematical formulation is a multiobjective optimization problem, which is restricted by general constraints such as land growth rates and zoning, whose objectives correspond to each of the stakeholders' interests. Together with the work in (Mogle, Gabriel & Faria, 2003), this multiobjective and novel approach applied to Smart and Inclusive Growth allows regional planners and other interested parties to balance the tradeoffs between the competing stakeholders.

Gilbert et al. (1985) developed a four-objective optimization model that also contained integer restrictions on the variables. Their objectives included: the acquisition and development cost, the amenity and detractor distances, and the shape objective. Due to their formulation's computational complexity, they developed an interactive, partial enumeration scheme.

This paper aims to establish a comprehensive concept to embrace the two aspects, content and processes, of inclusive planning practices. It suggests that the concept of the "inclusive city" provides a framework for the discussion of inclusiveness in urban planet, in terms of both outcome and process. It is also proposed not only a normative concept for new strategies to address the problem but also an analytical concept that is relevant in describing the problem. After establishing the concept, we review and evaluate the experiences of inclusive planning practices in light of it.

The rest of this paper is organized as follows: Section 2 presents the Smart and Inclusive Growth principles and its multiobjective optimization problem model; Section 3 describes selected numerical results for New Taipei City, Taiwan via the proposed model; and Section 4 summarizes our findings.

2. Smart and Inclusive Growth Principles and Model Formulation

UN-Habitat launched in 1999 The Global Campaign on Urban Governance where the central theme is the "inclusive city". They define the inclusive city as "a place where everyone is enabled and empowered to fully participate in the social, economic and political opportunities" and they stress that the major strategy for this vision is "participatory planning and decision-making" (UN-habitat, 2001). The inclusive city initiatives main emphasis lies in decision-making process for good urban golfing is rather than the final outcome, as implied by the campaign title (Beall, 2000; Stren, 2004).

The inclusive outcomes, however, maybe in tension with inclusive process, as the just city approach stressed. A simple inclusion of the under-privileged is not enough to guarantee equitable outcomes, but all depends on the situation of democracy where opposing interests compete (Fainstein, 2014). To solve this tension, we need to put the same emphasis on the content, i.e., equitable outcomes.

Smart and Inclusive Growth is an urban planning and transportation theory that concentrates growth in compact walkable urban centers to avoid sprawl. The theory can be applied to solve urban planning design problems (e.g., mixed-use infill development), to accelerate land use efficiency, and to manage urban growth (e.g., human population control). It also advocates compact, transit-oriented, walkable, and bicycle-friendly land use — e.g., neighborhood schools, complete streets — and mixed-use development with a range of housing choices. To implement this idea of Smart and Inclusive Growth, it requires a public-private partnership. By doing so, we will be able to achieve economic growth without having the ugliness, congestion, and environmental degradation. We will also be able to reduce wasteful public subsidies of sprawling development (Glendening, 1997).

So far, there is no one single definition of Smart and Inclusive Growth that satisfies everyone and many people have their own (Miller & Hoel, 2002). For example, Barbara McCann, the executive director of Smart and Inclusive Growth America, states that "Smart and Inclusive Growth is so many different things. It's not just transportation. It's a mindset towards creating a more holistic community. We've talked about quality of life. And what has been more fundamental to quality of life than physical health?" Another example, the National Association of Home Builders explains Smart and Inclusive Growth from a developers' perspective. The organization defines Smart and Inclusive Growth as "development that provides a wide range of different housing choices." That is, Smart and Inclusive Growth is defined as the development that provides: (1) a firm, comprehensive, open, and locally-based planning, (2) a more effective, innovative, and market-sensitive way of utilizing land areas, and (3) housing units according to economic and population projections. Though no two organizations define Smart and Inclusive Growth in precisely the same terms, the design principles of Smart and Inclusive Growth which are promulgated by the Smart and Inclusive Growth Network have gained widespread recognition. These principles are listed and described in Table 1.

Table 1 Design Principles of Smart and Inclusive Growth

Principle	Description
Mix Land Uses (SGP1)	-Supporting the integration of mixed land uses in communities as a critical component of achieving better place to live.
Compact Building (SGP2)	-Providing a means for communities to incorporate more compact building design as an alternative to conventional, land-consumptive development.
Variety of Housing Choices (SGP3)	-Providing a range of housing types, sizes, and prices.
Walkable Neighborhoods (SGP4)	-Creating walkable communities to live, work, learn, worship, and play.
Community with Strong Sense of Space (SGP5)	-Fostering communities with a strong sense of place to craft a vision and set standards for development that respect community values of architectural beauty and distinctiveness, as well as expand choices in housing and transportation.
Preserve Open Space and Critical Environmental Areas (SGP6)	-Open space preservation supports Smart and Inclusive Growth goals by bolstering local economies, preserving critical environmental areas, improving our community's quality of life, and guiding new growth into existing communities.
Infill Development of Existing Communities (SGP7)	-Directing development towards existing communities already served by infrastructure, seeking to utilize resources that existing neighborhoods offer, and conserving open space and irreplaceable natural resources on the urban fringe.
Variety of Transportation Choices (SGP8)	-Providing a wider range of transportation options in an effort to improve beleaguered current systems.
Cost Effective Development (SGP9)	-Embracing the private sector to help make development decisions to be predictable, fair, and cost effective.
Community-stakeholder partnership (SGP10)	-Encouraging community and stakeholder to jointly making development decisions.

Source: The official website of Smart and Inclusive Growth Network, http://www.smartgrowth.org/network.php

Smart and Inclusive Growth has rapidly raised its popularity in the past two decades because it is a type of development that has the following characteristics (Duany & Plater-Zyberk, 1992; Song, 2005):

(1) a street network circulation design that utilizes shorter street lengths in a grid-like pattern to promote better traffic flow

(2) higher density residential uses surrounding retail, recreational, and governmental uses

(3) more mixture of land uses that reduce the number of vehicle trips

(4) better accessibility to retail and transit that improves quality of life

(5) pedestrian-friendly neighborhoods

Although Smart and Inclusive Growth has gained its popularity, the application of design principles to community development projects has encountered implementation challenges. These challenges are brought up by individuals and organizations concerned with property rights, home building, the automobile industry, and agriculture (Knnap & Talen, 2005). Such opposition has inhibited the ability of urban planners, government officials, environmentalists, and real estate developers who promote Smart and Inclusive Growth to achieve initial project objectives (Downs, 2005).

Smart and Inclusive Growth principles are still relatively new and even the term "Smart and Inclusive Growth" still is a highly visible concept in public policy debates. It is touted as a framework for helping communities achieve a better, more equitable, and more affordable built environment. Edwards and Haines (2007) evaluate the use of design principles in a local comprehensive plan. The authors conclude that Smart and Inclusive Growth is most often narrowly described in terms of encouraging communities to support compact, mixed use, pedestrian-friendly, and ecologically sound development directed to existing built areas. Ye et al. (2005) also note that, beyond the categories of resource preservation and community development, most dimensions of Smart and

Inclusive Growth definition are urban focused. Their findings suggest that the Smart and Inclusive Growth paradigm needs more careful attention if it is to be successfully promoted to all communities. Many of the needs of rural communities seem to be left out of our standard definitions of Smart and Inclusive Growth and our array of policies to advance better planning (Edwards & Haines, 2007).

Despite many economic and political challenges faced by land planners and growth management advocates, there is much to be optimistic about the initiatives of Smart and Inclusive Growth and its view towards the planning and developing of communities. According to Chapin (2012), Smart and Inclusive Growth is an opportunity towards achieving desirable development outcomes.

To fairly represent the land development process, we model the objectives of four main stakeholder groups with competing objectives: government planners, environmentalists, conservationists, and land developers. At present, competing stakeholder objectives are not considered in most Smart and Inclusive Growth designs. Instead, a range of best management practices might be used. Examples include: incorporating porous pavement, rain gardens, or grassed swales (Schueler & Holland, 2000) in an effort to minimize the impact of development. In fact, Smart and Inclusive Growth may be made more complicated by the advocates of this strategy. Balancing the interests of the diverse stakeholders from a multiobjective optimization perspective involves some sort of compromise strategy that can be analyzed over many different time periods. The current work considers a snapshot of the tradeoffs between these stakeholders.

2.1 An Overview of the Multiobjective Optimization Model

Multiobjective optimization problems can be stated as

$$\min\{f_1(x),\dots,f_k(x)\}$$
$$\text{s.t. } x \in F \tag{1}$$

Where $f_1,\dots,f_k$ are given (real-valued) objective functions defined on some feasible region F.

Pareto optimal points can be generated by appropriate choice of these weights. However, no preferences are imputed with this method. That is, the weights do not correspond to how much each objective is valued; instead, the weights are a mechanism to obtain Pareto solutions. The weighted subproblem is given as

$$\min \sum_{i=1}^{k} w_i f_i(x)$$
$$\text{s.t. } x \in F, where w_i > 0, i = 1,\dots,k \tag{2}$$

For the multiobjective optimization problem concerning Smart and Inclusive Growth, we first designate S as the set of indices for each of the parcels of land that might be developed. For a typical parcel *i*∈*S*.

$$d_i = \begin{cases} 1, \text{if parcel } i \text{ is developed,} \\ 0, \quad \text{otherwise.} \end{cases}$$

Thus, fractional development of a parcel is not allowed. Since there are four stakeholder groups considered, the number of objectives is $k = 4$.

Additionally, for computational reasons, we consider only linear constraints with some binary variables (one or zero). Therefore, the form of the multiobjective optimization is

$$\min\{f_{\text{GP}}(x), f_{\text{E}}(x), f_{\text{C}}(x), f_{\text{D}}(x)\}$$
$$\text{s.t. } Ax \le b, \tag{3}$$

Where $f_{\text{GP}}(x), f_{\text{E}}(x), f_{\text{C}}(x), f_{\text{LD}}(x)$ are, respectively, the objective functions for the government planner, the environmentalist, the conservationist, and the land developer.

We have selected just one objective per stakeholder and have chosen linear objectives with the exception of the government planner whose objective (compactness) can be modeled as a convex, quadratic function. The resulting weighted problems of form (2), which we use to generate a representative subset of Pareto solutions, are convex, quadratic mixed integer programs. In many cases, these problems are tractable and solutions can be obtained in minutes. With this approach, the level of detail benefits the decision-makers involved in planning models because they can quantify actual tradeoffs, ordinarily very hard to measure, and can therefore make more informed decisions. Essentially, the role of operations researchers/management scientists in planning is to abstract very detailed considerations into something retaining a sufficient level of detail, yet is tractable. Our level of detail retains a certain degree of realism important for analytical reasons, while affording reasonable computational times, necessary for making our approach usable as a framework for the Smart and Inclusive Growth initiative. Additionally, enumeration of the entire Pareto set is not needed since a representative subset conveys the important tradeoffs.

2.2 The Government Planner

The government planner has several goals in land allocation consistent with Smart and Inclusive Growth. First, the planner is interested in developing key priority funding areas (PFAs). These sections have been targeted to promote redevelopment of blighted urban areas and maximize existing capacity for facilities (e.g., water, sewer). Second, the planner is interested in minimizing the low density zone land parcels to minimize sprawl. Third, the planner prefers to keep the land that is developed in as compact an area as possible. In this work only the compactness objective is considered.

2.3 The Environmentalist

The environmentalist has several objectives that can be optimized: maximizing the distance of developed land to streams to lessen the environmental impacts, concentrating development in hydrological unit codes that already have had substantial development, and minimizing the global change in imperviousness of the land development.

2.4 The Conservationist

The conservationist occupies the most environmentally friendly position along the spectrum of interests of the four stakeholders. This stakeholder is adamant about protecting certain key parcels from development.

2.5 The Land Developer

The developer is modeled to maximize the total value of the developed parcels where the value is calculated for a parcel i.

2.6 The Multiobjective Optimization Model

We adopted and followed the sample model formulation and computation processes partly from Gabriel et al. (2006) in our research. The resulting multiobjective optimization problem for Smart and Inclusive Growth will be as follows:

$\min(w_1 * z_1) = (r_{\mathrm{N}} - r_{\mathrm{S}}) \quad + (c_{\mathrm{E}} - c_{\mathrm{W}})$ (government planners)

$\min(w_2 * z_2) = \sum_{i \in S} (\Delta\_\mathrm{imperv}_i)(\mathrm{area}_i) d_i$ (environmentalists)

$\min(w_3 * z_3) = \sum_{i \in S} \mathrm{area}_i d_i$ (conservationists)

$\max(w_4 * z_4) = \sum_{i \in S_{11}} \mathrm{value}_i d_i + \sum_{i \in S_{12}} \mathrm{value}_i d_i + \sum_{i \in S_{13}} \mathrm{value}_i d_i$ (developers)

Subject to

$$d_i \in \{0, 1\}, \forall i \in S \tag{4}$$

Where z_1, z_2, z_3, z_4 are the objective functions of the four stakeholders; w_1, w_2, w_3, w_4 are the weighting for each of them. r_N, r_S, c_E, c_W are the points for North, South, East and West directions of a parcel. Δ_imperv_i is the imperviousness change of the land development. $area_i$ is the area of a parcel; d_i is the binary variables. Finally, $value_i$ is the predicted profit of the developer, and, S_{11}, S_{12}, S_{13} stand for residential area, commercial area and industry area individually.

3. Empirical Study

This section presents numerical results based on solving the multiobjective optimization problem (4) for land parcels in New Taipei City, Taiwan. Pareto optimal solutions to (4) can be obtained as solutions to the weighted version of the problem, which are instances of LONGO with many binary variables and constraints.

3.1 Database of Land Parcels for New Taipei City

Using a database of New Taipei City land parcel information in GIS format, both current and potential development of the area were analyzed. Figure 1shows the location area used in this study, comprising our database of 1372 previously developed parcels.

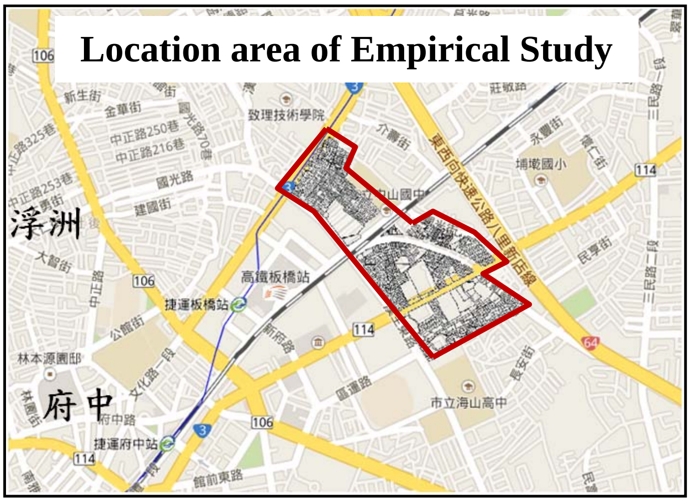


Figure 1　Location area of Empirical Study

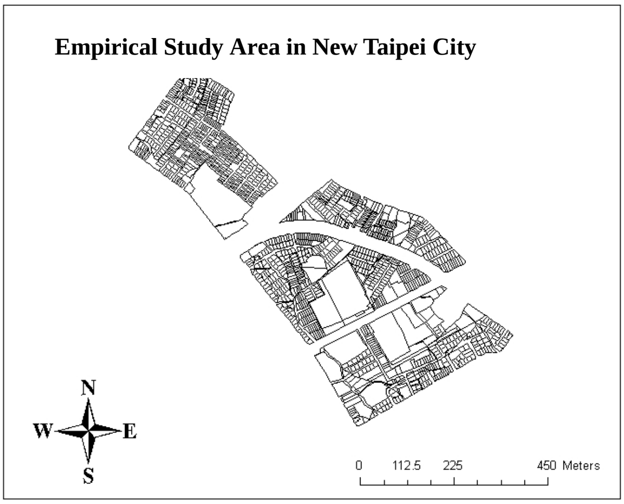


Figure 2　Empirical Study Area Database Segmented by Previously Developed Parcels (Gray) and Those Undeveloped Yet Available for Development (White)

3.2 Four Cases and Tradeoff Analysis

The section describes findings associated with Pareto optimal land development solutions to (4) using the weighting method. The resulting were generated and solved using the LINGO solver. In all, four sets of weights for the four stakeholders were applied; these weights are corresponding, respectively, to the planner, the environmentalist, the conservationist, and the developer. These four cases require different objective weights for the weighted problem as described.

Figure 3 shows the computation process of the LINGO Solver. Table 1 show our research results for the comparison of 4 different cases individually.

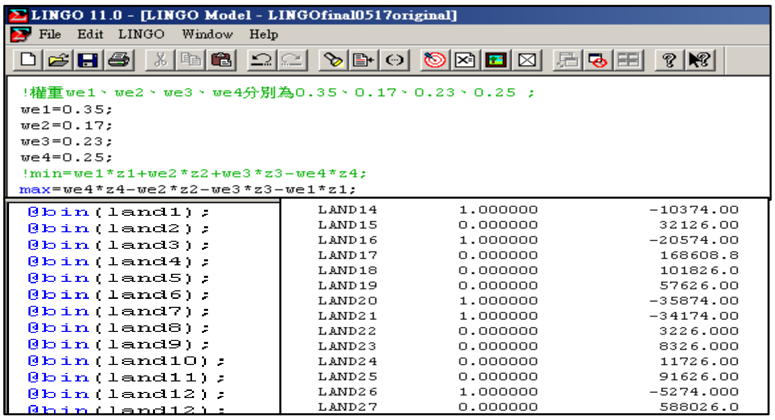
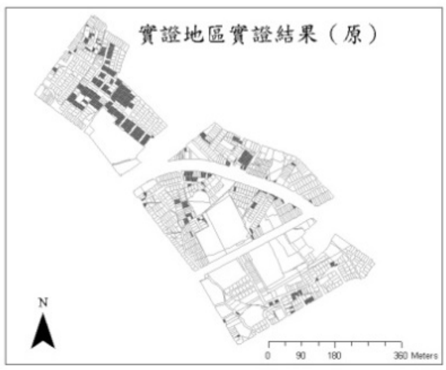
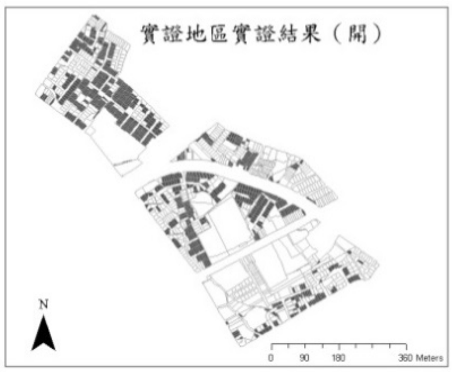
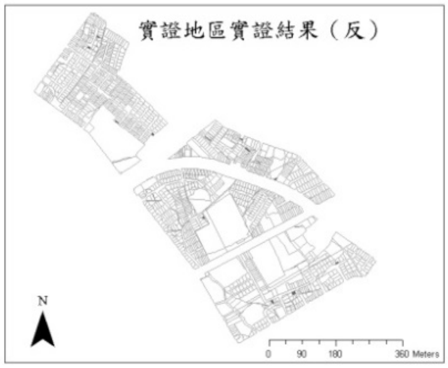
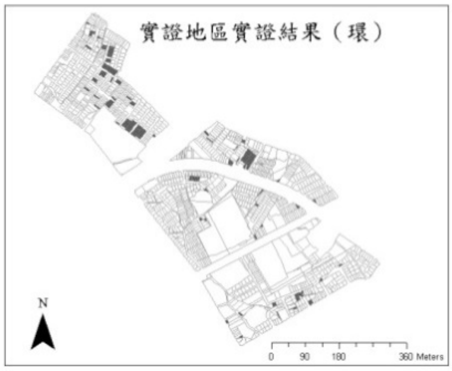


Figure 3 LINGO Solver Computation Process

Table 1 Comparison Results for 4 Cases

Cases	Weight priority	No.	Results	Maps
Original	The government planner	327	Concentrates on the upper left residential area	
Case 1	The land developer	725	Moving to the lower right residential area near the road	

Case 2	The conservationist	13	Fragmental distribution	
Case 3	The environmentalist	145	Concentrates on the upper residential area	

4. Concluding Remarks

Asia is notable for high level of persistent inequality and exclusion that are clearly manifested in urban areas (Beall, 2000; Kabeer, 2006). It may be true that social exclusion is a process rather than an outcome unlike inequality, but just outcomes are essential in achieving the goal of inclusive cities. Most of all, spatial inclusion should be secured immediately, as no further processes are possible without it. This condition may be effectively fulfilled through government-driven initiatives that are outcome-oriented. However, inclusive planning processes should also be pursued to establish good urban governance and to overcome the process of social exclusion, just as in the case of some Asia cities. The bottom line is that the inclusion city is both a process and an outcome that can be secured by approaching the problems from multi-dimensional perspectives.

In this paper we have presented a multiobjective optimization formulation for Smart and Inclusive Growth in land development based on recognizing the objectives of four different types of stakeholders: the government planner, the environmentalist, the conservationist, and the land developer. This paper presented potential objective functions that might be posed by these various stakeholders. The resulting model was applied in the context of an illustrative example for a GIS-based data set for New Taipei City, Taiwan.

This paper demonstrates the value of applying concepts of multiobjective optimization to the complex problem of Smart and Inclusive Growth and land use planning. The specific stakeholders identified and their proposed objective functions, while reasonable, are intended merely to illustrate how these concepts can be applied to this problem. The framework shown here can easily be modified to include other stakeholders' views or different objective functions. This process necessitates all those involved in the decision-making process to formulate explicit and quantifiable descriptions of their goals and constraints. Such formulations could serve to streamline discussions between different parties with a stake in the future development of a county or region.

This paper also demonstrated the value of GIS technology that involves a geographic component in addressing decision making. The GIS was used at the front-end of this analysis to derive and store the quantities that were the focus of each of the stakeholders' objectives, as well as many of the constraints. Further, after optimizations were completed, the GIS provided a visual presentation of the alternative outcomes associated with the nine illustrative scenarios that were considered.

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