

## **A dynamic adaptive decision framework: integrating transport and land use measures aimed at traffic congestion reduction**

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### **Abstract**

Much has been written about the desperate need to seek alternative solutions to the urban traffic congestion problems we face today. To manage these problems three main streams of intervention have evolved from supply, demand and land use management paradigms. Whilst their underlying measures all have the ability to reduce traffic congestion one way or another, little has been done to integrate the measures of each stream using a decision framework or process to facilitate the selection of site specific measures supporting local traffic and transport conditions. This paper reports the results of an empirical investigation by which a Multi-Criteria Analysis based dynamic adaptive decision framework was developed which screens through selected measures, identifying those that have the potential to alleviate site specific traffic congestion and transpose them into an integrated strategy. In assessing its usefulness and workability it was found to be capable of producing integrated strategies with the ability to manage traffic congestion, encourage sustainable development and alleviate some site specific development challenges.

*Keywords: land use, transport, integration, sustainable development.*

### **1 Introduction**

The failure to integrate land use and transport in traditional transport planning in cities has resulted in the decline of public transport and the ever increasing dominance of the private car. Growing traffic congestion is a major problem as road user demand keeps outstripping the supply of road infrastructure. In



response to the desperate need for alternative solutions to today's traffic congestion problems three main streams of intervention have evolved from supply, demand and land use management paradigms in forcing greater synergy between land use and transport. Decision makers are increasingly concerned about the environmental impact of planning proposals so it is considered important to devise approaches to planning that enables joined up decision making across a variety of sectors. The debates in recent years have focused on policy integration - developing integrated packages to overcome a wide range of transport and spatial planning externalities.

However, decision makers have sometimes found it difficult to identify the right mix of measures with regard to particular local conditions for inclusion in such a package or integrated strategy when attempting to manage or reduce traffic congestion. This paper presents the results of a recent empirical study aimed at identifying the considerations and components necessary to develop a Dynamic Adaptive Decision Framework (D.A.D.F.) or process that allows decision makers to select qualitatively the measures most applicable and appropriate to site specific conditions in managing traffic congestion whilst encouraging sustainable development.

## 2 Previous research

The concept of developing integrated strategies as an overarching approach to transport and land use integration is not a new one - attempts have been made to this end with varying degrees of success and for various purposes. However as Geerlings and Stead [1] suggest, less empirical work has been carried out to show whether progress has been made in developing integrated strategies aimed at traffic congestion reduction *per se*.

Previous research on the topic of policy or strategy integration is mainly technical and focuses on policy options, instruments or assessment methods, rather than on decision-making processes and/or implementation issues; little attention has been given to organisational and/or institutional aspects of policy integration and how this relates to theories from organisational, policy or political sciences. Indeed where such studies have been undertaken they reflect significant international differences in the way countries perceive and respond to traffic problems and subsequently the way in which they develop approaches that integrate transport and land use, suggesting that policy integration has varying degrees of success (Button [2]).

Because least developed and developing countries have an inability, for whatever reason, to plan transport systems, to manage travel demand, to relate land use and transport and to provide adequate resources for transport they struggle to implement integrated strategies. Envious exceptions have been reported from Curitiba in Brazil and the Lao People's Democratic Republic (Sawathvong [3] and Rabinovitch [4]). Their success lies in comprehensive and highly coordinated land transport policies, which combine the integration of land use and transport planning with demand management measures. The developed world has had more success in integrating Transportation Demand Management



(TDM), Transportation Supply Management (TSM) and Land Use Management (LUM) measures as examples from Toronto, Vancouver, Antwerp, Singapore, Edinburgh and London suggest all have in place comprehensive and highly integrated policy measures.

Over the last decade or so the approach to transport and land use integration together with a means of evaluating resulting strategies have been developed and accepted into practice by major UK studies as May et al [5] report. These studies have demonstrated that when an integrated approach, in which infrastructure provision, management of existing infrastructure and pricing of use of that infrastructure are coordinated, the scale of urban transport problems can be significantly reduced.

Less progress however has been made in providing a decision framework enabling decision makers to select optimal measures from a menu for inclusion in an integrated approach, which is best suited to site specific conditions and encourages sustainable development (Bell [6]). The lack of policy co-ordination and integration which are essential to ensure the implementation of packages of complementary policies rather than single measures is a key obstacle in producing integrated strategies particularly those aimed at reducing traffic congestion. The danger lies in the strictly sectoral approach to implementing TDM, TSM and LUM policies (Geerlings and Stead [1]) as has been the case in the past. It is not sustainable to implement a variety of measures on a piecemeal basis in tackling urban problems - integration of the measures is a prerequisite to force greater synergy where the sum of the total impacts is greater than the individual impacts of the measures. Only the development of highly integrated strategies with a clear decision framework has the potential to address the core of the problem.

### 3 Empirical research

In response to this need an empirical investigation was carried out to establish the considerations to be taken into account when developing a D.A.D.F. as well as the underlying components of the planning system in assessing whether and where integrated strategies should be connected to the planning system in operationalising the resulting integrated strategies.

#### 3.1 Considerations to be taken into account when developing a D.A.D.F. capable of producing sustainable integrated strategies

In developing integrated strategies, it is essential to be clear about what the strategy is designed to achieve and so it is essential to take account of specific considerations as part of a logical approach that will render the strategies sustainable. To this end the following key considerations must be built into the D.A.D.F.:

- Objectives allowing the decision maker to measure the extent to which their strategies contribute to sustainable development and traffic congestion reduction. Such objectives must capture the characteristics



or components of our understanding or what is envisaged to be achieved by sustainability (Jones and Lucas [7]).

- Impact criteria that measure the extent to which various options or measures contribute to meeting sustainability or policy objectives.
- Indicators that inform the decision maker about the extent to which various options or measures contribute to meeting the sustainability that goes beyond the United Nations developed Sustainable Development Indicator Framework.
- Thresholds and targets.
- Variables exogenous and endogenous to the transport system used to describe the settlement or scenario being planned for.

The investigation identified that the contributory elements of each consideration to be included in the D.A.D.F. ensuring integrated strategies contribute specifically to congestion reduction and more generally to sustainable development was less clear.

### 3.2 Operationalising integrated strategies

For integrated strategies to be operationalised it is necessary to identify the underlying components of the planning system so as to position the D.A.D.F. and its resulting integrated strategies within that system. From the Brundtland Commission's definition of sustainable development (Bond and Brooks [8]) it was possible to derive its four underlying dimensions. Integrated strategies must encourage and facilitate the movement of the dimensions towards full overlap as Figure 1 illustrates. By weaving together the dimensions, it presents a concise decision framework enabling sustainable development decisions to be made.

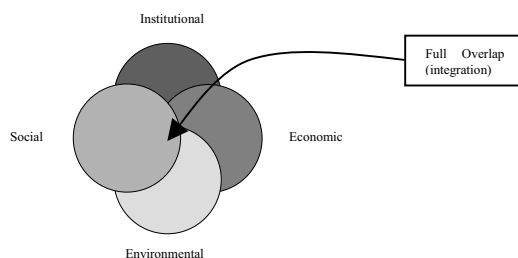


Figure 1: Dimensions of sustainable development.

To understand how the dimensions are related within the planning system they were transposed into the following inter-related components of the planning system:

- The planning system supported by an institutional framework that considers and promotes economic growth and social well-being.
- The menu of policy measures that helps attain sustainability and forms the underlying components of strategy integration.

- The environmental management framework within which planning decisions are made.
- The requirement of effective public participation reflecting the public mood and the sentiments of stakeholders in the development process.
- A funding framework.
- An appraisal framework assessing the impact of proposed planning policies.

In unravelling the components to assess whether and where the D.A.D.F. should be connected to the planning system in order to operationalise the resulting integrated strategies the following issues were identified:

- The success of strategy integration crucially depends upon the success of maintaining strategic control over local development processes, co-ordination between vertical levels of governance and horizontal support systems associated with each level of the administrative structure.
- Cross-sectoral integration within multi-layered governments is more successful when integrating a package of measures.
- Local Authorities are the most appropriate institutional level at which to implement local level decision making in both developing and developed countries. Some employ Integrated Development Plans (IDP's) as a mechanism to integrate spatial planning, land use management, transport planning and balancing those with environmental, economic and social concerns. In South Africa the Municipal Systems Act (No. 32 of 2000) requires all municipalities to prepare an IDP as a primary and overriding management tool that guides development at a local level. Sectoral, multi-sectoral and spatial plans are prepared within the national and provincial policy frameworks as set out in the relevant White Papers on Transport Policy and the ensuing land transport frameworks. It is imperative that these plans hang together in the IDP. In this sense, the IDP is an aggregate framework that provides a consistent rationale that coordinates and aligns sectoral functions (such as environmental management, spatial planning, land use management, housing and transport) promoting vertical and horizontal integration through a sustainable integrated spatial development process within the local municipal landscape.
- Because both IDPs and strategies aimed at traffic congestion reduction are formulated from a strategic perspective with a local level focus, the similarity provides a link and so the planning system through IDPs has the scope to operationalise a D.A.D.F. through an additional sectoral plan aimed at traffic congestion reduction per se.
- International experience suggests that not all measures are equally useful in reducing traffic congestion.
- The D.A.D.F. should be initiated from a strategic focus and the impacts of strategies developed assessed in terms of Strategic Environmental Assessment.
- Public participation can provide a better understanding of transport problems, help generate innovative solutions and be a key factor in

gaining public support and acceptability for the final mix of policies needed to deliver a strategy capable of addressing traffic congestion.

- It is important to include, as far as practically possible, self-financing measures in integrated strategies providing capital to fund capital intensive measures.

Having raised these issues it was subsequently necessary to identify the perspectives of stakeholders with regard to the appropriateness of an interface between the components of planning, integrated strategies and the D.A.D.F. If the interface were to be deemed plausible it will position the D.A.D.F. in the planning system and operationalise the resulting integrated strategies.

## 4 Methodology

In seeking the perspectives of a number of stakeholders the main drive behind the study was a survey and case study to collect the required data. The survey collected data components relevant to the contributing elements of each consideration required to develop the D.A.D.F. as well as revealed preference data in helping position the D.A.D.F. within the planning system. This process required comprehensive international sampling of National Departments of Transport, Spatial or Land use Planning departments, those national department tasked with the provision and maintenance of infrastructure, transport planning consultants as well as environmental interest groups. The survey was also aimed at (i) assessing planning's administrative and institutional framework in identifying the appropriate level of governance at which integrated strategies should be implemented and (ii) assessing the perceived value of linking integrated strategies into Integrated Development Plans via a D.A.D.F.

The case study was aimed at collecting data capable of testing the D.A.D.F.'s ability to produce an integrated strategy aimed at reducing traffic congestion in Cape Town and Johannesburg, where the strategy considered prevailing development challenges and objectives. Data was collected from both cities' Metropolitan Municipalities, Provincial Government, the National Department of Transport and transport planning and engineering consultants in South Africa. Once the case study data were input into the D.A.D.F. its results were transposed into integrated strategies for both cities.

## 5 Main findings

### 5.1 Connecting the D.A.D.F. to the planning system

In assessing the potential and appropriateness of connecting the D.A.D.F. to the planning system the findings suggested that the majority of respondents supported the notion. The findings demonstrated that by connecting the D.A.D.F. to the components of planning it is possible to create an interface between integrated strategies and the components of the planning system, thereby fully positioning the D.A.D.F. within planning. In going beyond identifying the connection to locating it, it was found that legislative provisions would have to



be made before implementation and that the D.A.D.F. would have to be positioned at Local Government level as both are associated with a greater understanding of local needs. Subsequently the integrated strategies produced by the D.A.D.F. can be related directly around local level aspirations, opportunities, needs, challenges and concerns. Because Integrated Development Plans present a mechanism that aligns sectoral functions and promotes vertical and horizontal integration and communication at local government level and the D.A.D.F. has a similar local level focus - it provides a useful interface between the D.A.D.F. and IDP's.

## 5.2 Components forming part of the D.A.D.F.

For the D.A.D.F. to be functional section 3.1 and 3.2 identified the considerations required to operationalise the process. Following the survey it was possible to establish the underlying components of each consideration. Table 1 illustrates some of the key components identified to be built into the D.A.D.F.

Table 1: Key elements to be assimilated into the D.A.D.F.

Objectives	Criteria		Variables	Guidelines and tech. considerations
Economy	Implementation cost	Exogenous variables	Parking provision	Vehicles/m <sup>2</sup>
	Economic efficiency		Population density per sq Km	Persons per sq km
	Economic growth		Cars per household	Number
Environmental protection	Emission level		Population size	Actual size (millions)
	Urban sprawl		Annual urban population growth	Rate in %
Liveable streets and neighbourhoods	Safe and secure neighbourhood		Housing	Density
	Contribution to investment in transport		Retail development	Location
Equity and social inclusion	Access to public transport		Economic growth	GDP per capita
	Community cohesion		Employment	Employment rate
Safety	Accidents		Access to public transport	Reduction or increase
	Danger		Air Quality	Reduction or increase
Integration	Impact on traffic congestion	Endogenous variables	Parking and Loading facilities	On street/off street
Accessibility	Ease of reaching opportunities		Traffic accidents	Reduction or increase
	Community severance		Travel time	Reduction or increase
	Access to the transport system		Construction and implementation cost	Reduction or increase
			Emission cost	Reduction or increase
			Transport interchange facilities	Reduction or increase
			Hub integration	Reduction or increase

## 5.3 The working of the D.A.D.F.

To enable the decision-maker to select the most appropriate measures capable of managing traffic congestion he/she must be able to measure the extent to which each option (measure) contributes to achieving sustainable development, traffic congestion reduction and local objectives which requires an assessment framework. To this end the data collected in the case study was organized, uploaded and structured within the MCA software BOSDA enabling analysis and trade-offs to be made between policy options. The appraisal process is illustrated by Figure 2. In essence the D.A.D.F. is a MCA based option analysis tool and process, where the option analysis stage of the standard MCA has been adapted to reflect three screening processes.



The first screening process measures the extent to which a variety of TDM, TSM and LUM measures contribute to achieving the sustainability objectives and higher order goal of traffic congestion reduction in terms of the criteria and indicators reported in Table 1. The screening process ranks the measures leaving the decision maker to decide on how many measures to transfer to the second screening process.

The second screening process measures the extent to which the remaining measures contribute to achieving the sustainability objectives against a set of generic first, second and third order effects and more specific effects associated with implementing those measures. Again the process reduces the number of appropriate measures for screening in the final process.

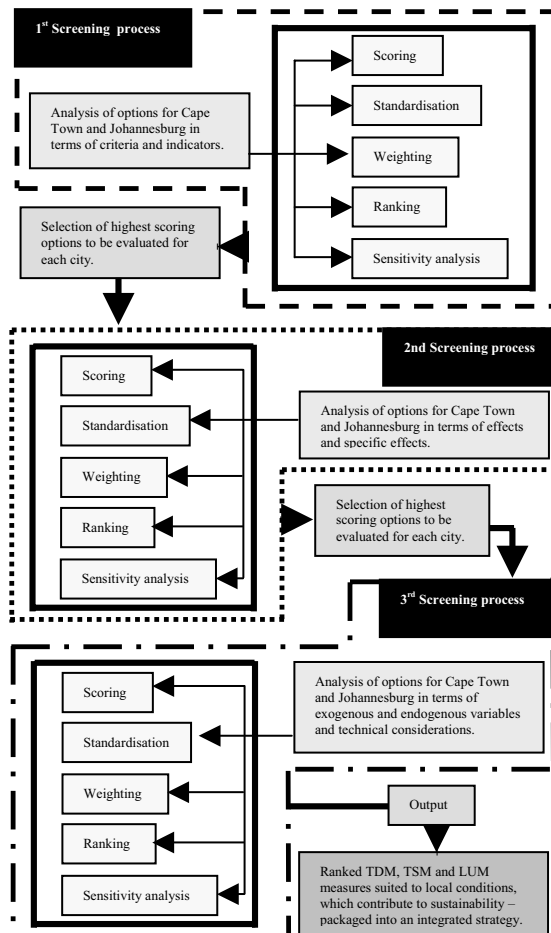


Figure 2: The D.A.D.F. appraisal framework for Cape Town and Johannesburg.



The third screening process is designed to identify the most suitable measures to be implemented under specific local conditions from the remaining measures. For the screening process to be dynamic and adaptive it measures the extent to which the final set of measures contribute to achieving sustainability in terms of exogenous and endogenous variables, guidelines and technical considerations (as illustrated in Table 1) reflecting prevailing conditions.

Essentially, the values of the exogenous and endogenous variables, guidelines and technical considerations give the screening process a dynamic and adaptive characteristic as the values and weights assigned to the variables are site specific. As an appraisal method it is therefore flexible in that the components of the structure such as the criteria and indicators, the classes of effects and more specific effects and the exogenous and endogenous variables, guidelines and technical considerations can be varied to meet local requirements therefore allowing the selection of measures suitable to a particular location.

#### **5.4 Assessing the usefulness of the D.A.D.F.**

Once the D.A.D.F. was structured it was applied as part of a case study in assessing its merits as a tool capable of producing integrated strategies for Cape Town and Johannesburg. This meant populating the D.A.D.F. with locally derived input data and running it through the software. In this way integrated strategies for Cape Town and Johannesburg were tailored to their local conditions. It was also possible to position the resulting integrated strategies within both cities' context in identifying its implications with due regard to historic development, strategic perspectives, development concerns and planning challenges.

Closer analysis of the integrated strategies revealed that it comprised a well balanced mix of LUM, TDM, TSM and Smart Growth measures. This result is therefore consistent with and supports the notion that integrated strategies have the potential to deliver a sustainable outcome when strategies draw on the synergy between its individual components. The 5 highest ranking measures in Cape Town's strategy were (i) car-free planning (ii) development encouraging use of public transport (iii) high development density aimed at travel reduction (iv) the development of travel plans and (v) the provision of effective and reliable public transport. Significantly though, the four highest ranked measures of Cape Town's integrated strategy are LUM measures suggesting that land use management and spatial planning is of fundamental importance in providing direction to other types of planning in dealing with traffic congestion in the context of Cape Town.

The 5 highest ranking measures in Johannesburg's strategy were (i) car-free planning (ii) the development encouraging use of public transport (iii) the development of travel plans (iv) effective and reliable public transport and (v) public transport orientated development. The combination of highest ranked options in Johannesburg's integrated strategy comprises a balanced mix of the four types of measures suggesting a different focus. There are similarities between the content of the integrated strategies of the two cities – largely because both share similar trends in development challenges. Fundamentally, the



outcome demonstrates that (i) it is possible to develop integrated strategies aimed at traffic congestion reduction through the D.A.D.F. (ii) the D.A.D.F. identifies measures that are suitable to local conditions (iii) it is possible to produce integrated strategies that are consistent with broad local planning goals and aspirations.

In further assessing the usefulness of the D.A.D.F. the findings demonstrated that the integrated strategies developed for both cities support their more specific urban perspectives and provide options capable of alleviating some of their development challenges in addition to traffic congestion reduction.

## 6 Conclusion

This paper has shown that by drawing on the synergy of a multitude of appropriate measures produced by an integrated strategy, the strategy becomes more than just a tool capable of alleviating traffic congestion, but also a mechanism that contributes to the development of sustainable transport, more efficient spatial development and a tool capable of addressing development challenges. Because the D.A.D.F. can be connected to the planning system through IDP's it provides the transport planning process with a refreshed ability to produce sustainable transport systems, where the emphasis is placed on the integration of land use, transport and the supply and management of transport infrastructure – tipping the scale away from car dominance.

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