QUANTITATIVE METHODS FOR ESTIMATING LAND USE SHIFTS

Most projects will influence land use to some extent, but the fundamental question is, “How much of a change?” When collaborative judgment indicates that land use effects may be sufficient to affect traffic or environmental outcomes, then the project team should take a “hard look” at the issue using some level of quantitative analysis. Additionally, where collaborative judgment does not produce a clear consensus and/or better validation is needed, quantitative approaches provide additional data-based support.

Quantitative analysis does not require sophisticated, integrated transportation-land use models; such models often are not readily available and do not offer a comprehensive solution. Rather, quantitative analysis comparing future build and no-build scenarios can be performed using GIS analysis, accessibility variables, and other variables established in literature as relating to land use effects. Many approaches are available for linking land use and transportation; selection of the appropriate method will depend on the project circumstances, available data, and the need to analyze effects unique to the project.

Method Description

Quantitative methods for estimating land use shifts often go by the name “land use allocation models” because the methods allocate land use among different geographic areas, such as traffic analysis zones (TAZs), for the travel demand model’s GIS-based dataset, and they do so in a relatively automated fashion.

These allocation methods apply a set of rules about how to allocate the land use among the geographic areas. These rules are developed based on factors that influence land use development, such as data on accessibility and other variables that may attract or constrain land use.

An allocation method approach is likely to be combined with other methods to provide the full array of necessary information and adequate validation. For example, collaborative expert judgment is used to create the rules and validate the results for reasonableness.

The allocation method used should be responsive to the types of changes that the project might be expected to make, enabling the necessary analysis of effects. The type of information used in allocation models may include the following:

- Existing land use by geographic unit (e.g., parcels, census geographies, TAZs and/or uniform units of acreages such as 10-square-acre grid cells).
- Population, households, and employment by geographic unit
- Existing zoning, including allowable densities by land use type
- Planned land use (from comprehensive or general plan)
- Environmental constraints including water bodies, wetlands, parks, and other areas protected from development

- Carrying capacity as calculated from land use and/or environmental data
- Availability of water and/or sewer infrastructure
- Distance and/or time proximity to transportation facilities
- Distance and/or time proximity to points of interest such as employment centers
- Other attractiveness factors such as school district information, property tax information, etc.

Applicable Contexts

Land Use Allocation Methods are generally employed when a comparison of future land use forecasts is needed with some degree of geographic specificity, generally, if alternative land use or travel forecasts are needed for the build, no-build, or various project alternatives' scenarios.

Typical examples of application of the method include:

- Providing a quantitative assessment of induced land use effects
- Providing a basis for effects analysis, particularly in relation to environmental resources (such as water quality) that are sensitive to changes in land use

Prerequisites

1. **Established Consensus That Build and No-Build Land Use Differ.** Quantitative allocation methods will primarily be used to identify meaningful, quantifiable differences in land use between the build and no-build conditions.
2. **Established Consensus Regarding What Condition (build or no-build) is Represented by Existing Land Use Forecasts.** To apply the method(s), the study team must establish whether the existing forecasts represent the build or the no-build condition, as a means of establishing what alternative land use forecasts are needed. [See summary sheet on Unbuilding the Build scenario for more information on that context.]
3. **Framework for Land Use Attractiveness Factors**. The framework must link transportation and land use, but may include other factors. The framework is developed via literature review, growth factor analysis, and/or Collaborative Judgment to assign attractiveness factors in the allocation method in a manner that fits the project context.
4. **Data for Land Use Attractiveness Factors**. Using the framework for measuring land use attractiveness, gather data for measuring the relevant factors. This will also include transportation data necessary to reflect the transportation-land use connection, such as congested speeds on the network for the build and no-build conditions.
5. **Alternative Growth Control Totals for Build and No-Build (if necessary -- uncommon).** The study team must determine if alternative growth control totals are applicable in the analysis, and if so, what they are. Considerations include the magnitude of the project's impact on total network mileage (for example, see Duranton and Turner[i]) and other assessments of the project's ability to affect regional growth.

Examples of Method Implementation

The selection and implementation of specific methods will depend on the context of the project. The examples that follow illustrate approaches appropriate for different project contexts across a logical spectrum. Other types of projects and contexts can be surmised from these examples.

Rural Highway in an Area with No High-Speed Facilities

A project that substantially improves access in an area that is experiencing low or modest growth can be anticipated to induce changes in land use in those areas benefiting from the access improvements (e.g., near interchanges), depending on other factors influencing the suitability of the land for development. If the project is a bypass of an established community, the analysis should also consider effects on the areas being bypassed in addition to the areas benefiting from the new access.

1. Establish a framework for the analysis using a literature review and analysis of comparable cases. Collaborative Judgment should be used but not exclusively because perceptions of new growth along the highway and/or impacts to established communities may not match empirical research and should be tempered accordingly. One appropriate option is the Hartgen Method for Estimating Growth at Rural Interchanges.
2. Gather objective data that the method will use to understand the attractiveness and/or suitability for development, such as: traffic volumes, analysis of accessibility, and availability of water and sewer infrastructure in the present and in the reasonably foreseeable future.
3. Estimate the land use changes and review them with local planners. Use *Collaborative Judgment* to refine and validate the results.
4. Document data, methods, assumptions and results.

Large Scale New-Location Highway in Rapidly Growing Metropolitan Area

At the other end of the spectrum is a situation where high levels of growth are forecasted, fueled by a strong regional economy, and a large-scale new facility is proposed. Depending on the scale, this could be a situation in which historical research methods (e.g., Duranton and Turner*)* or regional economic models may be used to estimate alternative regional growth control totals.

1. Establish the drivers of growth and the relative importance of accessibility in location decisions.

a. Research the regional planning agency's basis for allocating regional land use forecasts to TAZs; review all documentation and identify the framework for allocation. If no framework is available, then conduct a literature review and comparative case analysis to develop an appropriate framework, or consider using a gravity model. Gravity models allocate land use based on the relative "gravity" of different geographic areas, based on the factors the model uses to estimate the likelihood of development.

b. Collaborative Judgment should be used to develop the basis for land use attractiveness factors, for example by interviewing regional and local planners and gathering or developing data that represent the future build and/or no-build condition. (See "Creating a No-Build Scenario from a Build Scenario"

Methodology Sheet).

As referenced in NCDOT's ICE Guidance document (2001), a gravity model can be used to allocate study area population and employment control totals to TAZs based on calculation of land available for development in each zone (i.e., capacity) and the change in accessibility to other zones with and without the project. Accessibility is calculated from zone-to-zone travel times produced by the project's travel demand model.

2. Gather any objective data required for the method such as traffic forecasts, land suitability and availability of water and sewer infrastructure. If needed, conduct accessibility analysis.
3. Apply the land use allocation framework or gravity model using the alternative attractiveness factors to create the appropriate land use scenarios.
4. Thoroughly document all methods, data, basis for decisions, and results.

Highway Improving Access to Lower-Growth Area of a Growing Region

A situation in which a project has the potential to shift regional growth dynamics is challenging. The approach must carefully differentiate how the proposed change in accessibility will affect future land use, as distinct from other factors.

1. Begin with a growth-factor analysis to understand the regional growth dynamics and growth drivers (such as land values) that may be influenced by any substantial change in accessibility.
2. Follow the steps described in the previous example, with an emphasis on identifying the effects of an accessibility change in light of the relative differences that presently occur between the study area and other parts of the region. Consider not only attractiveness but also constraints or deterrents to growth in the study area that may factor into the differences between build and no build. If the growth dynamics are straight-forward, consider the Gravity Model method to re-allocate growth on the basis of accessibility changes and other factors determined to be significant.
3. Carefully document any rationale to hold the regional growth total constant or to consider alternative control totals for build and no build.

Documentation

The project documentation should explain the rationale and empirical basis for selecting methods, including any process to choose among multiple available methods. Provide a record of the data and assumptions used in the method selected, such as the source and vintage of all source data. Record any interaction of the allocation method with other methods employed to develop assumptions for the analysis (i.e., literature review or Collaborative Judgment), and any validation of the results through primary or secondary sources.

To the extent practicable, the method and results should be disclosed to an extent that they are not only transparent, but replicable.

Findings must also be clearly documented, ideally including graphical representation of the build and no-build results that support the environmental effects conclusions.

Resources

AASHTO Center for Environmental Excellence. (2015). *Case Law Update Details - Monroe Connector/Bypass.*

https://environment.transportation.org/clue/case_details.aspx?case_id=196

Avin, U.; R. Cervero, T. Moore, C. Dorney. 2007. NCHRP Report 25-25 Forecasting Indirect Land Use Effects of Transportation Projects. http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25(22)_FR.pdf

Duranton, G., and M.A. Turner. 2012. Urban growth and transportation. The Review of Economic Studies, 79(4):1407-1440 FHWA. 2018. Instructions for Reviewing Travel and Land Use Forecasting Analysis in NEPA Documents. https://www.environment.fhwa.dot.gov/nepa/Travel_LandUse/forecasting_reviewer_guidance.aspx.

FHWA 2018 Reviewer Instructions, p. 13, 15, re traffic forecasts: to account for conditions that "were not considered when the MPO forecast was prepared." [ii]

FHWA. 2000. Toolbox for Regional Policy Analysis Report. https://www.fhwa.dot.gov/planning/processes/tools/toolbox/methodologies/land_develop_overview.cfm,

Hartgen et al. 1992. *Growth at Rural Interchanges: What, Where, Why*. Transportation Research Record 1359.

ICF 2005, page 26 http://onlinepubs.trb.org/onlinepubs/archive/NotesDocs/25-25%283%29_FR.pdf

Maryland State Highway Administration's Indirect and Cumulative Effects Analysis (ICE Analysis) Guidelines. 2007 https://www.roads.maryland.gov/OPPEN/SHA%20ICE%20Guidelines.pdf

NCDOT Guidance for Assessing Indirect and Cumulative Impacts of Transportation Projects in North Carolina. 2001. https://connect.ncdot.gov/resources/environmental/compliance%20guides%20and%20procedures/volume%2001%20assessment%20guidance%20policy%20report.pdf

NCDOT. (2001). *Guidance for Assessing Indirect and Cumulative Impacts of Transportation Projects in North Carolina, Volume II: Practitioner's Handbook,* p III-50. https://connect.ncdot.gov/resources/Environmental/Compliance%20Guides%20and%20Procedures/Volume%2002%20Assessment%20Guidance%20Practitioners%20Handbook.pdf

Texas Department of Transportation Guidance Indirect Impacts Analysis. 2016. http://ftp.dot.state.tx.us/pub/txdot-info/env/toolkit/720-02-gui.pdf

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[i] Duranton, G., and M.A. Turner. 2012. Urban growth and transportation. The Review of Economic Studies, 79(4):1407-1440

[ii] FHWA 2018 Reviewer Instructions p. 13.