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# Spatial implications on land and resources of new road infrastructure in Suriname: land use scanner

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*Abstract: In the sparsely populated country of Suriname, South America, plans are being made to develop the infrastructure and connect Suriname with Brazil via a new road straight through the country's pristine forest area. Geoinformation plays a crucial role in assessing potential spatial changes in land and resources resulting from these new infrastructural plans. The implications for people living in these affected areas can be demonstrated by visualizing potential impact areas on maps that are accessible for all.*

## Introduction

In December 2010 a memorandum of understanding (MoU)was signed between the Suriname government and Chinese company "China Harbor" to investigate the possibilities to construct a road and a railroad connecting the capital city of Paramaribo in the North of the country, to Brazil. Other parts of the MoU include e.g. the possible development of a deep sea harbor. These intentions suggest a focus on transport of bulk goods such as mining products and timber from the interior of Suriname, possible from Brazil as well, to the north of the country. Implications of the plans are not know yet, but modeling possible spatial impacts of these new infrastructural works demonstrates where changes in land use could occur in the future.

In this article we describe the development of the modeling process of the new road infrastructure for Suriname, using the "ClueScanner" tool.  Spatial awareness of the possible implications of such a new road among local stakeholders can be achieved through the publication of maps (web based, or in paper format) and by developing educational modules to explore impacts in the local livelihoods. Only when all stakeholders have the same information at their disposal, a meaningful discussion can take place.

First we will explain the data collection necessary to set up a spatial model of the new road infrastructure in Suriname. The resulting maps are made accessible for the public through the EduGIS website. Finally we will present the results of the spatial modeling exercise.

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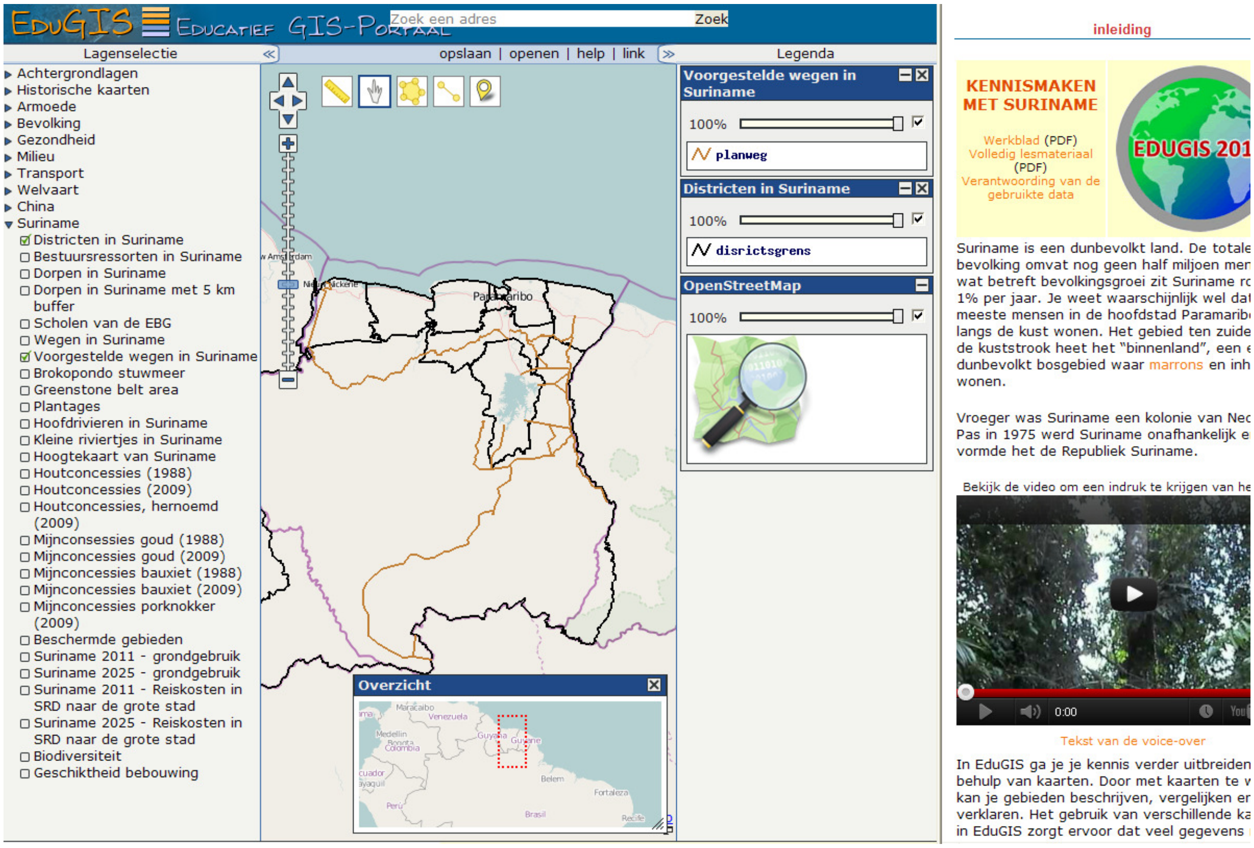
## Data collection

The construction of infrastructural works, such as roads, has mayor spatial impacts on future land use patterns. A road opens up previously less accessible areas, which makes the area attractive for various forms of economic exploitation. It becomes more attractive to harvest wood, it enables bulk transport as well of mining products, it open ups new opportunities for small and large scale agriculture, previously peripheral villages get better and cheaper connections to the centre. In such areas, land speculation is likely to occur by people who expect profits by claiming vast tracks of land in these areas as concessions for timber or mining extraction. Several methods exist to model such spatial impacts of infrastructural works.

Before starting the process of modelling, spatial data had to be collected. Data and maps stem from different sources. There are many examples of participatory mapping projects by local stakeholders (http://www.amazonteam.org, Suriname), but predominantly nongovernmental organizations and especially governmental bodies are the main producers of digital information and maps. In the Surinamese case study, data has been collected from sources as the Centre of Agricultural Research of the ADEK University of Suriname), the Foundation for Forest Management and Production Control, and the Department of Geology and Mining of the Ministry of Natural Resources. The trajectories of the proposed news roads and location of the dams are based on existing paper map plans. These maps have been digitized and geo-referenced. Information on the data can be found at http://www.edugis.nl/lesmodules/Suriname/metadata.html. The maps were placed on the public EduGIS website, so everyone can see, by combining map layers, where village territories overlap with the planned infrastructural works, or where the future roads would cross through which concession areas. In the figure below (Figure 1) one can distinguish all the different maps that have been collected at the left side of the menu under “lagenselectie”. Each map can be displayed in the screen, and different map layers can be combined, depending on the interest of the user: e.g. one can combine a map with location of the new road, with the villages and the concession areas. To explore the datasets or maps, an educational module has been developed, to be found at the right side of the menu.

*Figure 1: EduGIS website, Suriname section*




More challenging however is to use these GIS maps to model the possible future spatial impacts of such new infrastructural works. A model that generates images of possible effects based on different scenarios, and that calculates spatial impacts of policy alternatives is a valuable tool in the decision making process. For this exercise, the ClueScanner model has been used.

## Modelling of the impact area

Once the optimal routing has been established we attempt at measuring the impact of the road on the territory that is trespassed as it will develop in the course of time.  Many SEAs apply ex ante limits to impact areas as observed in this study, like mountain ranges, wide rivers, and national borders. Border areas in particular have been excluded from SEAs while the creation of international linkages may induce significant change in areas at both sides of the border.

Among the models available for assessing the probable impact area of a road the so-called ClueScanner is used. This GIS based land use model generates spatial projections for alternative scenarios, depending on a series of variables related to land suitability, physical factors, infrastructure, markets, population concentrations, and government policies.

The ClueScanner model is a spatial explicit calculation instrument for making projections of future land use. The basic assumption is that multiple land use types (built area, agriculture, forest, nature, water etc.) compete for the same limited amount of land. The regional demand and the local suitability for the land use type determine the price a land user is ‘willing to pay’ for a specific land unit. The land units are modelled as grid cells. The ClueScanner is used in a case study for Suriname, to model the effects of new infrastructure (roads, railways, waterways) on land use changes.

Figure 2 represents the used model of land use change for this study.

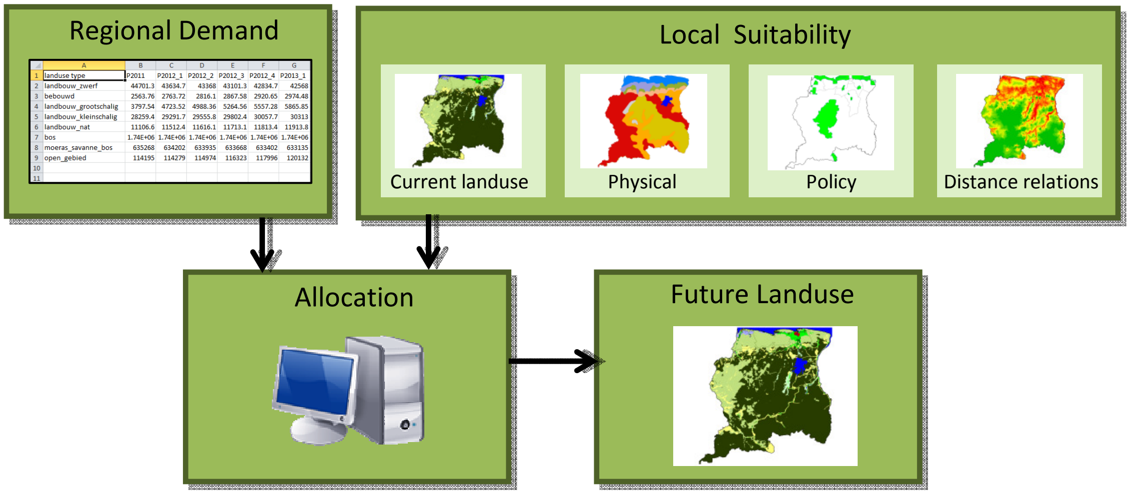



*Figure 2: land use model as used in ClueScanner study for Suriname*

**Regional Demands** are projections of the total amount of land use (change). These projections are land use type specific. Sources for these projections can be sector or demographic models (demographic growth usually results in a higher demand for built up areas and agricultural land). The demands can also be based on expert knowledge.

The **Local Suitability** is modelled for each land use type at the land unit level. It may incorporate a large number of suitability factors referring to various aspects such as:

- current land use: the suitability of a land use type for a land unit is often higher if this land use type already occurs in the land unit in the previous period. Especially for land use transitions which high costs (for example if new housing areas need to be build), this can be a substantial factor. The presence of the same land use type in the neighbourhood often also increases the suitability, for example because new housing areas make use of services of adjacent housing areas.
- physical properties, such as altitude, slope and soil type. Flat, low-lying land units are often relative more suitable for built up area, infrastructure and intensive agriculture, as the construction and maintenance costs are relatively low.
- planning policies, such as protected areas, materials and concession policies determine the suitability of areas to be exploited and developed.
- distance relations to nearby features, such as towns, harbours, roads or rivers determine the suitability especially if transport costs are relevant.

The suitability of land units is affected by nearby improvements of roads. In the Suriname applications, new roads will reduce the travel times from the inlands to Paramaribo from 24 hours to less than 8 hours. The improved accessibility will increase the suitability for land use types differently. This implies that some land use types are assumed to pay higher prices for the land units that become more accessible. In the allocation module, these higher prices will, ceteris paribus, result in the allocation of built area and agriculture nearby the new roads. This pattern corresponds to what can be observed on existing maps.

The **allocation module** allocates the land use types according to their local suitabilities, taking the claims as preconditions that need to be fulfilled. If the claims cannot be fulfilled, status information on why no feasible solution can be found is presented. The allocation model uses a discrete allocation function, resulting in one land use type for each land unit. More information on this function can be found at: [http://wiki.objectvision.nl/index.php/Discrete_Allocation](http://wiki.objectvision.nl/index.php/Discrete_Allocation). To calculate the results, the GeoDMS software is used. The GeoDMS is a modelling framework that supports a controlled and efficient calculation process, especially useful for large spatial datasets. In the Suriname case study allocation results are calculated for more than 4 million grid cells and dozens of suitability factor maps within one minute.

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## Results

The result of the model is a projection of the **future land use**. In the ClueScanner this usually means a projection for several time steps of one year or smaller. Animation techniques can be used to visualise the developments, using the future land use of the time steps as input. An example of a result map is presented in figure 3 below.

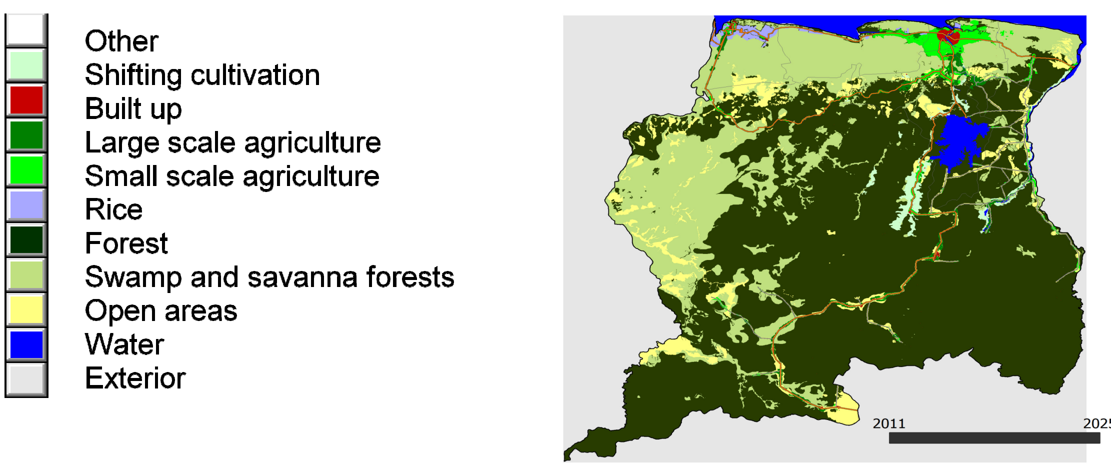


**Figure 3 Land Use Suriname 2025**

The results of the model indicate that at some locations along the new projected road, there is a low impact to be expected within 500 m road buffer, whereas other locations demonstrate a high impact within a four kilometer road buffer. These maps and animations can be used for discussion with stakeholders and for the development and evaluation of spatial policy plans.

The focus of the ClueScanner is on the spatial allocation of land use change. The model does not predict the total amount of demographic growth nor the prices of materials. The strengths of the ClueScanner are that it can:

1. Determine whether the demands can be satisfied simultaneously
2. Allocate and map spatial distributions with maximum suitability of land use types
3. Help to evaluate the impact of spatial distribution

The model is developed in the Netherlands, a country in which land use changed is mainly influenced by spatial planning due to the high pressure and interactions of land use. Investment decisions usually have a time horizon of multiple years, both in terms of realizing a project as well as in payback time. In policy rich environments, the model therefore usually calculates in one or a few time steps of 10 or 15 years. In this context the name Land Use Scanner(RuimteScanner in Dutch) is used.

To support modelling natural processes as factors for land use change, the model is made dynamic with time steps of one year or smaller. The suitability factors are classified as static (constant during the projection period) or dynamic (dependent on the allocated land use in the previous period, or from other sources that differ over the projection period). This dynamic approach has been used in the Suriname case to model the effects of the different stages of infrastructure development on land use change.

The ClueScanner is an integral model for analysing the effects of different scenarios on land use change. Within a scenario infrastructure developments can be an important aspect as well as demographic growth or spatial policy options. The model is less suitable for predicting the exact location of where a road will be build, but is suitable for projection the effects on development of built up areas and agriculture nearby new infrastructure as well as deforestation and mining, taking into account also other relevant developments modelled in the scenarios. The resulting animations are available at: http://www.objectvision.nl/projects/suriname-new-infrastructure.

## Conclusions

With the application of the "ClueScanner" based on the new road plans in Suriname, we demonstrated that geoinformation plays a crucial role in assessing potential spatial changes in land and resources resulting from these new infrastructural plans. To asses interactions with natural, technical and social factors, powerful instruments are needed for linking information from different sources by location.

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