ASSESSING ENVIRONMENTAL-IMPACTED FEATURES OF EIA STUDY IN CORRIDOR PLANNING BASED ON GIS AND REMOTE SENSING TECHNOLOGIES

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RESUMO – Análise de Impacto Ambiental involve análises técnicas que consideram fatores do projeto que podem influenciar de modo positiva e negativa o ambiente. O estudo de impacto ambiental fornece informações para planejamento e projeto, além de assugurar que os gestores possam conhecer de antemão e considerar aspectos sociais, biofísicos e outros que sejam relevantes ao projeto antes que as decisões sejam tomadas. O objectivo é reduzir impactos do projeto no meio ambiente. Em Transportes, estudos de impacto ambiental são normalmente conduzidos ao ao logo de corredores compreendendo as differentes alternativas de estrada em estudo. Todas as informações ambientais relevantes que intersectam o corredor, tais como áreas alagadas, cruzamento com rios, áreas residenciais ou sítios arquiológicos por exemplo passam a ser quantificados e considerados no estudo. Considerando que projetos em transporte necessitam aqsição de áreas extensas, o emprego adequado de tecnologias atuais de sensoriamento remoto e pelo Departamento de Transportes dos EUA reduz efetivamente o tempo e o custo do processo ambiental. Esse artigo ilustra a metodologia para acessar e trabalhar com feiçoes espaciais normalmente empregadas no relatório de impacto ambiental utilizando dados comerciais de sensoriamento remoto e Sistema de Informação Geográfica. Bases de dados espaciais existentes para hidrografia, geologia, cobertura e uso do solo são combinados e utilizados para demonstrar como podem oferecer ao processo de análise ambiental melhor desempenho. O trabalho foi desenvolvido no trecho de concessão de número 9 da Rodovia Interestadual 69/269 (anél viário recém contruído na cidade de Memphis, Tennesee). Por fim, os valores encontrados são comparados ao números apresentados no relatório de impacto ambiental.

ABSTRACT - Environmental Impact Assessment (EIA) involves technical analysis considering positive and negative influences on a project related with the environment. EIA projects provide information for planning and design, therefore ensure decision-makers to consider biophysical, social, and other relevant aspects prior to major decisions being taken. The goal is to reduce adverse impacts and design to suit the local environment. In transportation, EIA is normally performed along the corridor buffers constructed for the alternatives of the proposed road. All the relevant environmentally-related features intersecting these buffer zones, such as wetlands, rivers-crossings, settlements, archeological sites, cemetery are considered in the study. Since transportation projects require substantial area, the appropriate use of current remote sensing and spatial technologies in USDOTs effectively reduce time and cost demanded on EIA. This paper addresses a methodology to assess and work with the environmental-impacted features using commercial remote sensing and GIS technologies. Existing national coverage databases of hydrology, soils, and land use are combined. The results show that these data can mitigate potential environmental-impacted features for an alternative segment. The research is been conducted on SIU-9 of I-69/I-269 as a test-bed. Finally, the resultant environmental-impacted features are compared with the existing features using a matrix.

1 INTRODUCTION

Environmental Impact Assessment (EIA) is a formal process of predicting the environmental consequences of any developmental engineering project which requires precise information to offer recommendations that helpful for

decision makers. In transportation corridor planning, environmental costs are estimated based on the severity of the impact of features along the corridor. Thus, to connect point A to point B, several segments are normally designed and their respective alternatives are ranked according to the cost of the impact on their environmental severity. Regarding the features evaluated on EIA which, some of them are gathered from existing published vector databases as land use, hydrology and soil composition. Not only good geo-databases are currently available for the usage of EIA studies, but also commercial remote sensing and spatial information technologies are (crst&si) integrated with modern methodologies to extract features of interest based on these new data. The usage of modern geo-technologies and its new solutions have motivated environmental practitioners around the world further more into exploration. Transportation corridor planning is certainly one of those fields to be benefited.

This paper addresses an innovative approach based on the combined use of rich existing geodata and land use information from crst&si and compares the traditional approaches employed to assess environmental impacted features in EIA studies. The goal acquires precise and up to date information about land use as well as assessing environmental information which is helpful for EIA and NEPA studies making use of remote sensing ad GIS technologies. The study area is located on the proposed bypass road near Memphis-TN as reported in (FEIS). A collection of high quality geodata including very high resolution aerial photo, multispectral aerial and orbital images and a high detailed digital elevation model from LiDAR are engaged.

2 THE SIU-9/I-69'S CASE STUDY

The Interstate 69 is a 1,600 mile long corridor proposed to connect Canada to Mexico across the Unites States. The overall project was divided into 32 Segments of Independent Utility (SIU) for studies purposes, where each state is responsible for the segments within their state boundaries. The SIU-9 EIS was conducted jointly by MS and TN Departments of Transportation in a way that considered the main I-69 segment as coincident with the existing I-55 while a new transportation loop would connect Hernando, MS to Millington, TN. traversing Memphis, TN, to the east as showed in Figure 1.

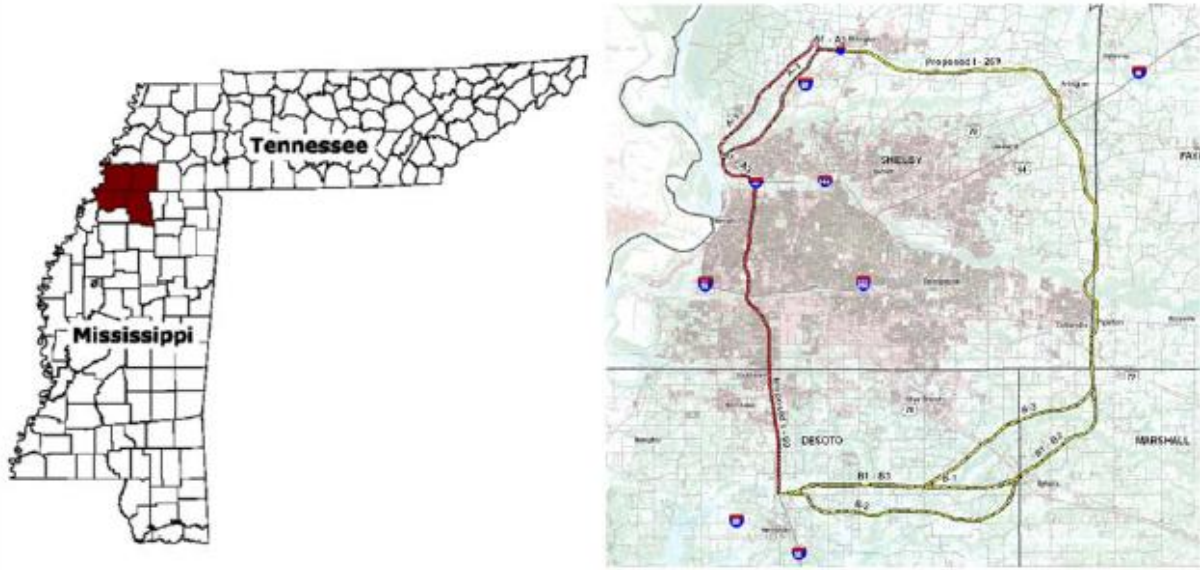

Figure 1 - I-69 General location of the study area (left) and the proposed SIU-9 with the respective proposed bypass (right).

The recently completed EIS for SIU-9 serves as the research test bed for NCRST-SEPP to quantify benefits delivered by remote sensing and spatial information technologies over traditional approached to transportation planning practices. The experience of the NCRST-SEPP team has demonstrated the importance of acquiring high quality geodata. Fortunately, for the study area within northwest Mississippi and southwest Tennessee there exist a variety of high quality geodata from diverse sources. Thus, not only availability of the data is considered here, but also the potential uses of data, limitations, and data types are described according to specific environmental analysis for which data sets may be useful in analysis applications.

3 THE TRADITIONAL APPROACH AND THE PROPOSED ONE

In general, transportation practitioners have been developing EIA studies considering the alignment corridor as a baseline and the right of way areas surround them. The environmental impacted features inside the corridor buffer are taken into account for EIA analysis. This process requires on ground survey and local analysis, but a part of the information comes from existing geodata. Transportation planning practitioners have good geodata like high resolution aerial images to conduct their work most of the time. Unfortunately in many cases the images are used as background where information is gathered manually and by combining them to give results using GIS. The Figure 2 shows an alignment study based on traditional approaches.

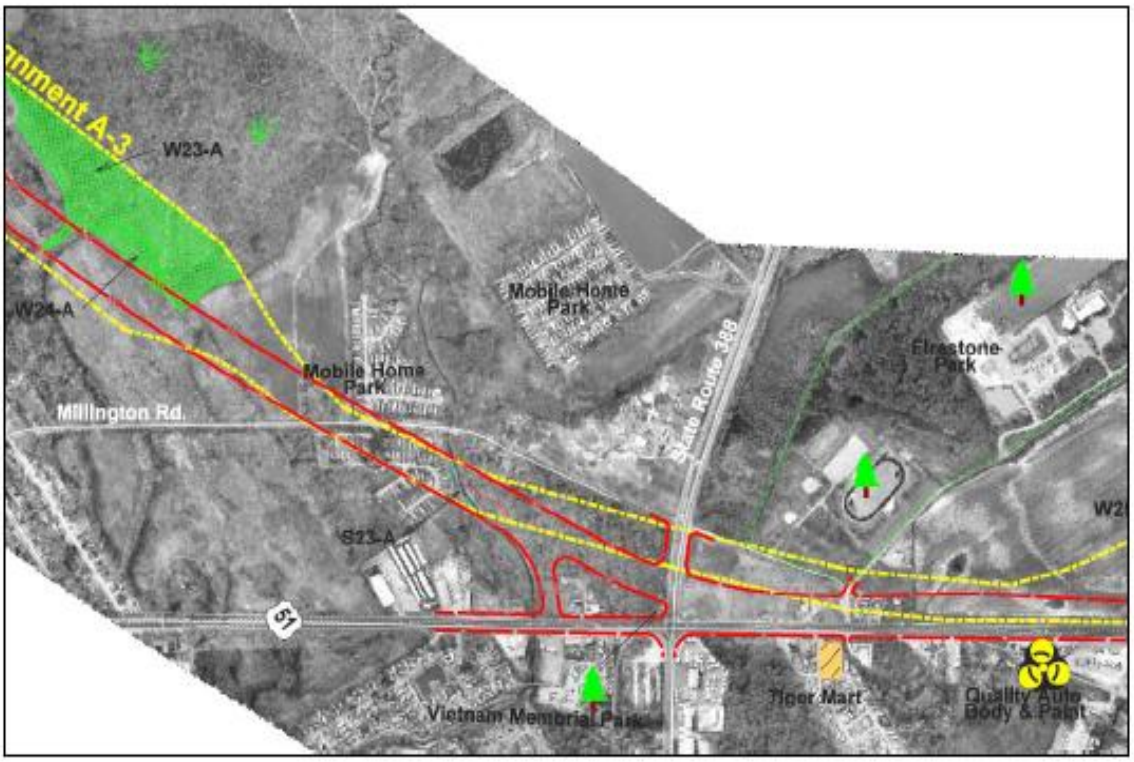

Figure 2 - Sample of alignment study for transportation corridor planning. Some relevant land use and community services information are considered. (Federal Highway Administration, 2006)

Innovative technologies in terms of image processing have demonstrated impressive results for land cover and land use classification using high resolution multispectral imagery. The methodology proposed in this paper is with multispectral imagery and object-based image classification. This work is a part of Streamlining Environmental and Planning Processes (SEPP), a project funded by the US DOT Research and Innovative Technology Administration (RITA). As part of National Consortium for Remote Sensing in Transportation (NCRST-E), SEPP employs significant technology in geo-information. For this particular effort, high resolution multispectral imagery and LiDAR data are used in combination with existing vector information through object-based classification. Putting together these resultant images, dense and updated digital elevation data becomes possible to identify minor details which could never be reached before using traditional approaches in transportation corridor planning unless rigorous ground surveys were done.

The study also used multispectral imagery from the National Agriculture Imagery Program (NAIP), from que US Department of Agriculture. These data are public available and contain the well known visible RGB colors plus, more recently, the infrared information. It produces amazing results in terms of vegetation coverage and water delineation. Object-based image classification is a modern way to extract information from digital image while considering not only the spectral aspect, but also contextual one. Objects are primarily identified on image using color information. Secondarily shape and contextual information are added to the model to refine the classification rules. This permits to acquire not only land cover, but also land use. Also, the existing vector database can be included into the model as constraints. Object-based classification supports multisource data for the analysis, so methodology described for the NAIP imagery can easily be transferred to optical imagery from other sources.

4 COMBINING SOURCES OF GEO-INFORMATION: THE TRADITIONAL VS PROPOSED WAY.

The most environmental impacted features reported on EIA studies regards to hydrograph, wetlands and natural habitats. For planning purposes, most of these can be reached remotely from aerial and/or orbital data, as well as from existing published data. Figure 3 shows some relationship between hydrograph, wetlands and natural habitat and the source data. Extracting hydrograph, wetland and natural habitat information do not require complex solutions. However, it required just simple tools and methods already existing. GIS-based analyses are normally used to integrate multi-source information due to the large amount of data and large area of transportation corridor planning.

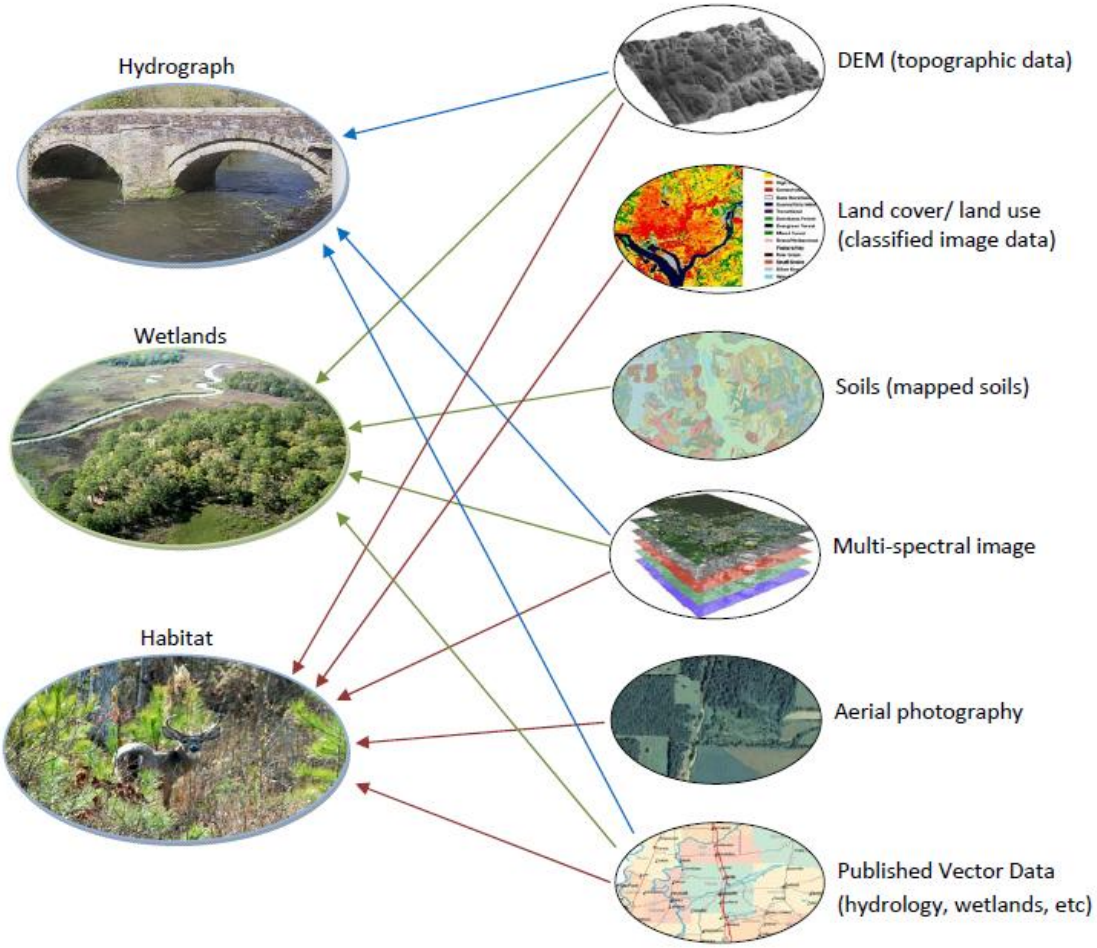

Figure 3 - Relationship between the environment scenarios of EIA study and sources of geodata

Considering the needs of EIA, getting information from published vector dataset looks the simple and easier solution. Unfortunately however, the published vectors databases , as well as the high resolution public available imagery are not always existing for the area of the project. In this case , a robust solution on assessing EIA information can not considered as primary source. Land-use layers, because of the global availability, can easily supply this gap. However, the tradition per-pixel image classification methods used in remote sensing do not allow to achieve deep detailed information for transportation planning purpose, resulting in poor or inefficient land cover map for EIA.

In order to overcome this problem, object-based image classifications are used. The method combines modern and powerful way to compute data from different sources to produce land cover map, even existing maps dn anciliary information. As an illustrative way, wetlands are easily reached from multispectral image, added to digital elevation model, and so on added to hydrograph published databases and other data, as shown in Figure 4.

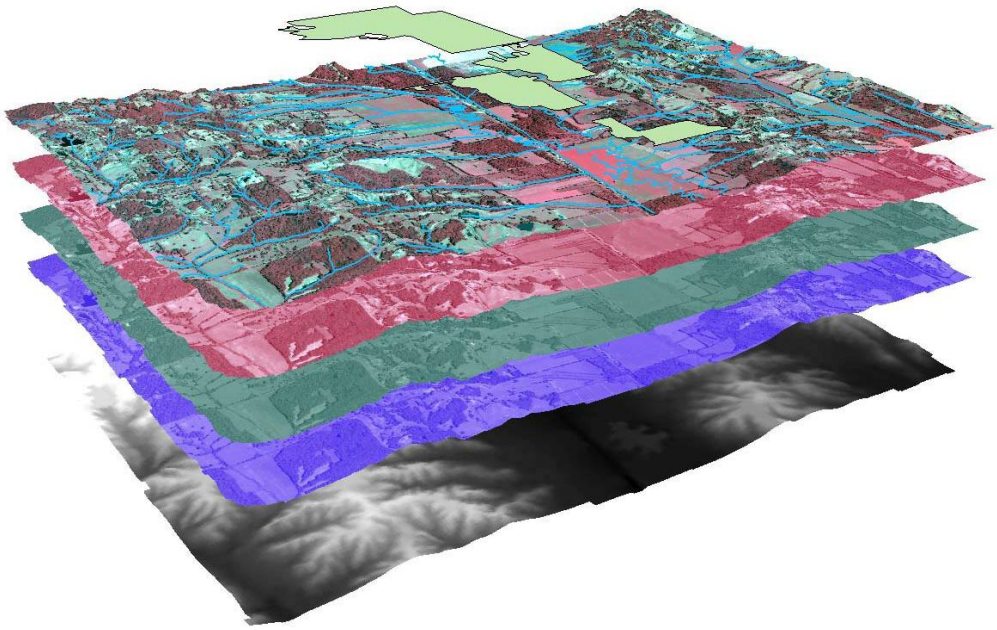

Figure 4 - Extracting wetlands from multispectral images, DEM and published hydrograph

5 RESULTS

This paper emphasizes the use of GIS and remote sensing-based extraction within the transportation corridor. The method and data used were selected based on availability and free-of-cost. The overall idea characterizes practical uses towards time saving and cost benefit for the USDOT transportation practitioners. Using this approach quantification of the features extracted as meaningful indicator related with the transportation planning process and comparing with the results of traditional methods. Results of past projects of Geosystems Research Institute as well as the literature review have demonstrated the efficiency of object-based image classification used. The Figure 5 illustrates how the project team employed existing datasets.

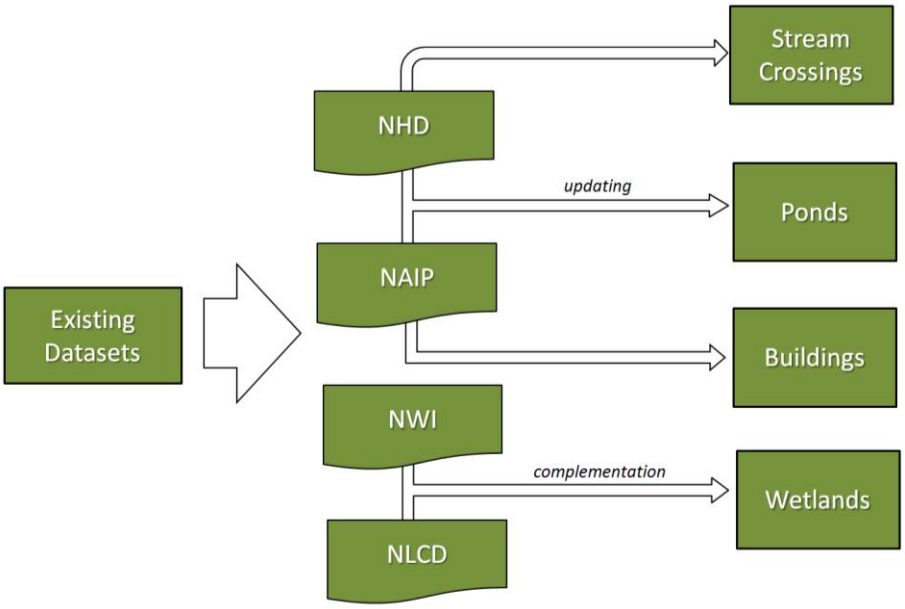

Figure 5 – Gathering the best available geodata. (Nobrega et all, 2009)

The results describe a considerable advantage in use Remote Sensing and existing GIS data for early-framework in the Transportation EIA studies. For this study, Federal data provided a conservative basis for screening environmental constraints that were consistent across possible alignments. Spatial data sets included nearly twice the features or lengths or areas for factor considered than were reported in the I-69 / I-269 Final EIS, as illustrated in Figure 6 and quantified in Figure 7.

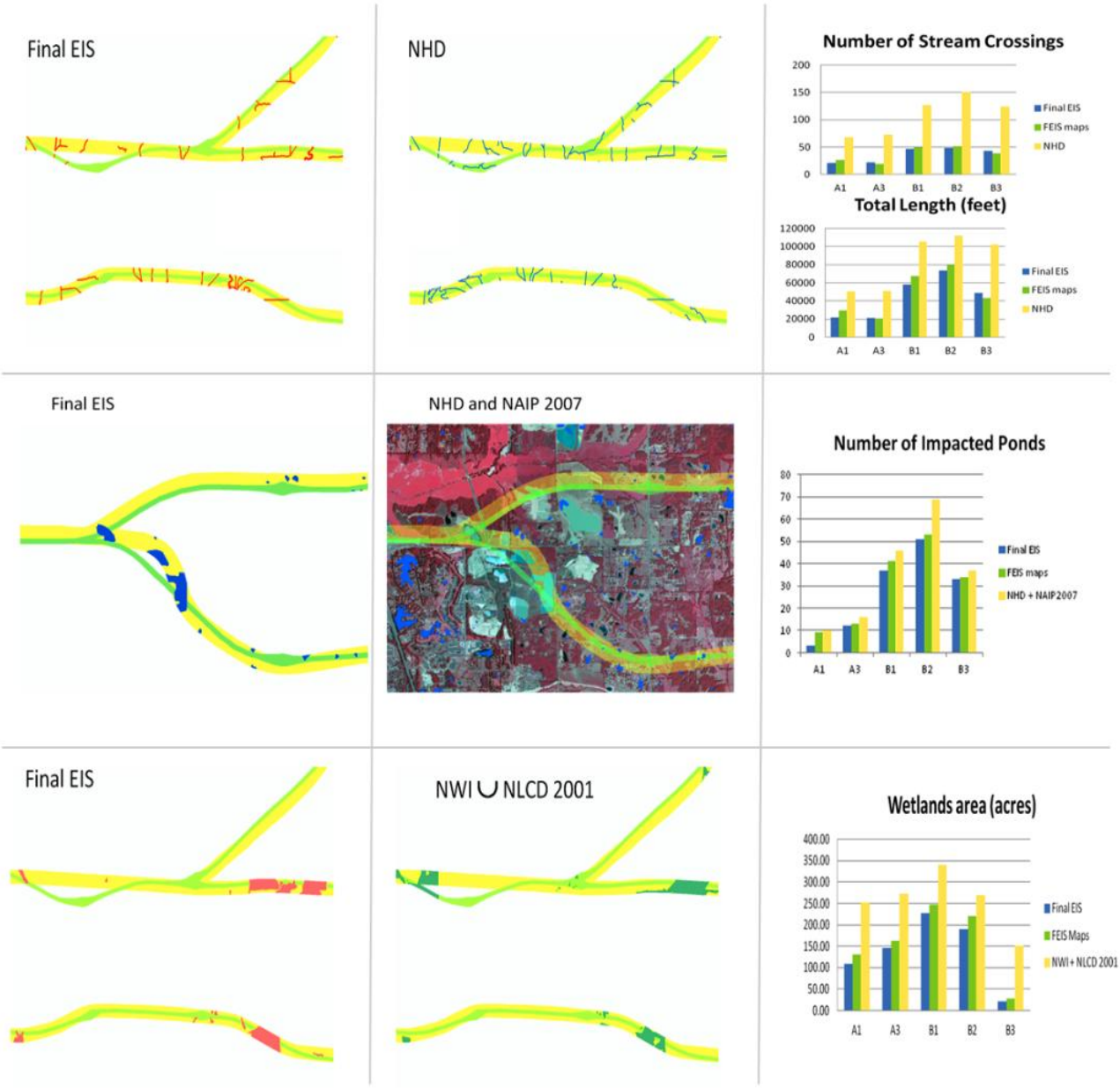

Figure 6 – Comparative analysis between the geographic features presented in official Tennessee/Mississippi DOT Environmental Impact Statement and the geographic features extracted from GIS and Remote Sensing data available in the same period that the EIS was conducted. First row reports river-crossings, in second row the waterbodies and in third row the wetlands. (Extracted from Nobrega et al, 2009)

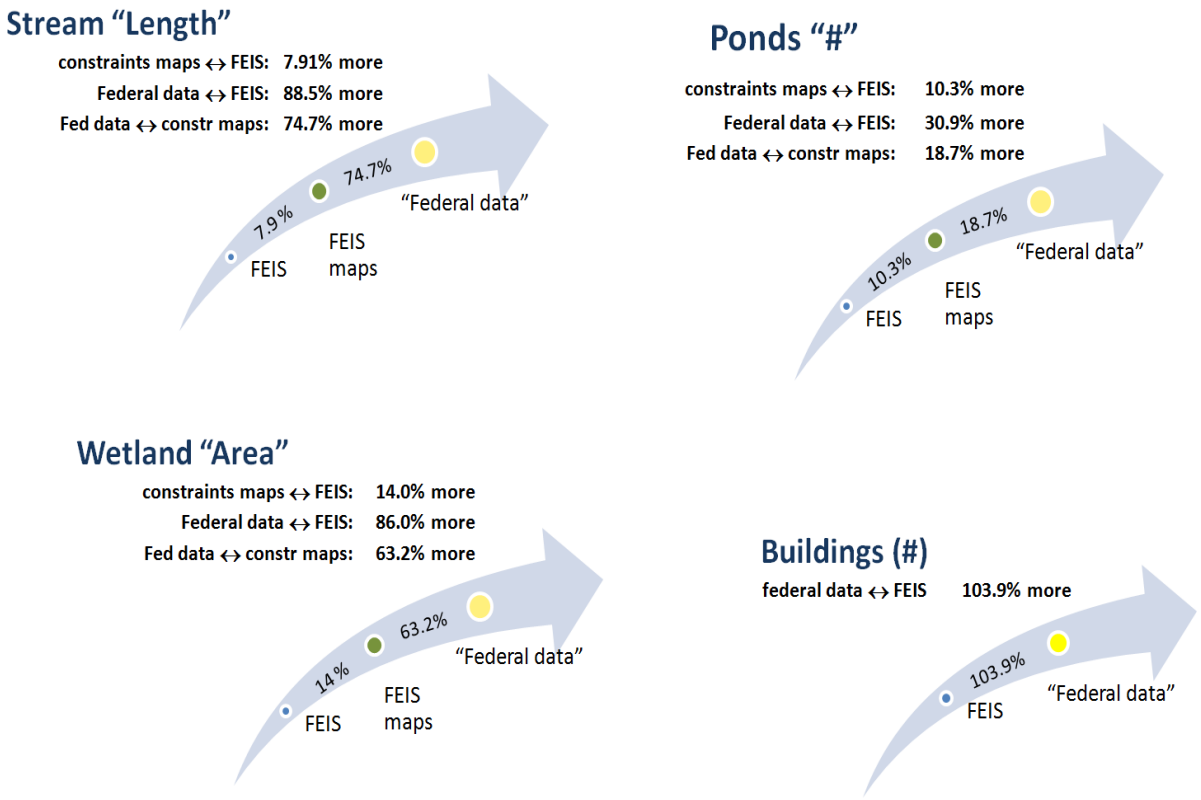

Figure 7 – Comparative analysis between the geographic features presented in official Tennessee/Mississippi DOT Environmental Impact Statement and the geographic features extracted from GIS and Remote Sensing data available in the same period that the EIS was conducted. (Extracted from Nobrega et al, 2009)

6 CONCLUSIONS AND FINAL CONSIDERATIONS

From the rising initiatives of DOT point of view on promoting and supporting emerging issues in terms of research and technology, the paper proposes a methodology to efficiently mitigate environmental impact on transportation system. Transportation corridor always requires large extensions of land and the mitigation process demands long time. Aiming to reduce time and imminent costs, the paper propose the use of remote sensing and GIS technologies to produce the information necessary for EIA studies.

The SEPP project of NCRST-E aims to offer improvements on transportation corridor developments. Knowledge gained with this study project will be absorbed into DOT scope. Reducing time and increasing quality on transportation corridor planning is one of the goals set by DOT and it's the major challenge could be done using this work.

ACKNOWLEDGEMENTS

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REFEFERENCES

FEDERAL HIGHWAY ADMINISTRATION. Final Environmental Impact Statement of Section of Independent Utility 9 of Interstate 69. **FHWA-TN-EIS-04-01F**, Department of Transportation, 2006. 297p.

FONSECA, A., GOLVEIA C. Environmental Impact Assessment using multimedia GIS. **Proceedings of EGIS'94**, Fifth European Conference on Geographical Information Systems, Paris, 1994. 12p. http://libraries.maine.edu/Spatial/gisweb/spatdb/egis/eg94047.html

FÜRST, J. Overview of GIS software and products. Course notes for lecture series "**GIS in Hydrology and Water Management**, University of Natural Resources and Applied Life Sciences, Vienna, 2008. http://iwhw.boku.ac.at/gisww/bokudownloads/downloads.htm

HARVEY, F. Developing geographic information infrastructures for local government: a rule of trust. **The Canadian Geographer**, Canadian Association of Geographers, 47, n.1, 2003, p. 28-36.

KING, R. L.; O'HARA, C. G. The National Consortium on Remote Sensing in Transportation –Environmental Assessments. **Geoscience and Remote Sensing Symposium**, 2001. IGARSS '01. IEEE 2001 International. Sydney, Australia, 2001. P. 1820-1822.

O'HARA, C. G. Remote Sensing and Geospatial Applications for Wetland Mapping and Assessment. Proceedings: **ASPRS Integrated Remote Sensing at the Global, Regional and Local Scale / Land Satellite Information-IV - Pecora 15 Conference**, Denver, 2002. 13p. http://www.isprs.org/commission1/proceedings02/paper/00079.pdf

MILLER, H.J., Han, J. **Geographic data mining and knowledge discovery**. Taylor&Francis, New York, 2001. 372 p.

NOBREGA, R. A. A., SADASIVUNI, R., O'HARA, C., DUMAS, J. Evaluation of environmental impacted features from traditional approaches versus remote sensing and GIS based approaches for EIA study on transportation planning. **Proceedings** of ASPRS Annual Conference 2009, Baltimore-MD

NOBREGA, R. A. A. Deteccao da malha viaria na periferia urbana de Sao Paulo utilizando imagens de alta resolucao especial e classificacao orientada a objetos. **Tese de Doutorado**, Escola Politecnica da Universidade de Sao Paulo, Sao Paulo, 2007. 166p.