

COST EFFECTIVENESS OF CONVENTIONAL VERSUS LANDSAT LAND USE DATA FOR HYDROLOGIC MODELING

Water Management and Control ASVT
Final Report

PREPARED FOR

National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland

PREPARED BY

Thomas S. George
Robert S. Taylor

WATER RESOURCES ENGINEERS
an Operating Unit of Camp Dresser & McKee INC.
Springfield, Virginia

September 1980

II. SUMMARY AND CONCLUSIONS

STUDY SUMMARY

The purpose of this chapter is to summarize the findings of the study and to present specific conclusions and recommendations that can be drawn from this work. A detailed analysis of six case studies has been performed to investigate the cost effectiveness of using Landsat obtained land use data as opposed to conventionally obtained land use data in hydrologic modeling. Five of the six case studies are Corps of Engineers Expanded Flood Plain Information (XFPI) investigations carried out by Corps Districts throughout the United States. The other test basin is one that is used as a training site for courses in hydrology and flood plain management presented by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers in Davis, California. For each case study information was collected on the methods and costs associated with obtaining land use information by conventional means for use in the hydrologic modeling phase of the XFPI reports. In addition, information on costs and procedures was also obtained for developing the required land use information based on a methodology that relies on Landsat imagery. This study compares these costs and develops a procedure to investigate the relative effectiveness of the two alternative means to acquire land use data needed for the hydrologic modeling.

The cost of obtaining the conventional land use data is shown to range between \$3,000 - \$16,000 for the six test basins. The corresponding resultant cost associated with obtaining the land use information based on Landsat imagery are \$2,000 - \$5,000. Thus, from a pure cost standpoint the Landsat approach for gathering land use data has a cost advantage in some cases. The next aspect investigated in this study is the relative effectiveness of each approach.

Based on the criteria developed during the course of this study for evaluating the various measures, the overall results of the effectiveness analysis show that the differences between the relative effectiveness of the conventional and Landsat methods for obtaining land use for hydrologic modeling purposes for each of the six test watersheds are insignificant. Therefore, the conventional approach is not generally more effective than the Landsat approach, nor is the Landsat approach generally more effective than the conventional approach.

This effectiveness analysis is not performed under the most ideal conditions. The emphasis has been placed on the effectiveness of conventional and Landsat methods for developing land use data for hydrologic analyses. All of the conventional studies, except Castro Valley, were part of an XFPI study which developed land use information for additional purposes. The Landsat land use development was only carried out to be applied to hydrologic analyses. However, the analysis of effectiveness is carried out with these differences taken into consideration as much as possible.

From the cost comparison and the fact that each method, conventional and Landsat, is shown to be equally effective in developing land use data for hydrologic studies, the cost effectiveness of the conventional or Landsat

method is found to be a function of basin size for the test watersheds analyzed. Castro Valley, a watershed of 5 square miles is definitely cost effective using the conventional method. Trail Creek with its 12 square mile area and the fact that the conventional cost may be underestimated, is a borderline case. The remaining watersheds show that the Landsat method is cost effective.

COST EFFECTIVENESS CONCLUSION

The total cost effectiveness analysis shows that there exists a point near 10 square miles in study area size where the conventional and Landsat methods depart as to their cost effectiveness. As a general conclusion, the cost effectiveness study, although limited in its number of test watersheds and performed under other than ideal study conditions, shows that for developing land use information for use in hydrologic studies the conventional method is cost effective for watershed study areas containing less than 10 square miles and that the Landsat method is cost effective for areas containing more than 10 square miles.

SUMMARY OF FINDINGS

Several additional specific conclusions and findings can be extracted from an analysis of the work performed in this study. They are grouped into two major categories as follows:

Study Findings

- This study presents conclusions based on six case studies and its validity depends entirely on the relatively small sample, however, previous research concurs with the findings of this work;
- Conventional land use classification costs per square mile of study area decrease as area increases;
- Land use classification costs by the use of satellite imagery for basins the size of those in our study is not highly dependent on the size of the basin;
- If existing land use data are scarce the cost of obtaining new land use data are much higher for conventional techniques than by Landsat means;
- The cost for HEC to perform Landsat based land use classification were nearly identical to the contracted costs for the same work;
- For large basins and large storm events hydrologic models are relatively insensitive to land use classifications, however, for small basins and/or small storms the model results (flows) become very sensitive to the land use employed;

- Use of the Landsat classification approach requires some special skills which are not presently standardly available in all technical offices dealing with hydrologic studies;
- Landsat imagery does not presently have the resolution required to do detailed land use classification for use in flood damage surveys or have the resolution needed to represent small areas with very diversified land uses;
- For detailed flood plain studies it would appear to be a cost effective approach to use Landsat derived land use for hydrologic calculating and to supplement this land use data with more detailed information in the actual flood plain area for use in economic analyses; and
- It is not feasible to attempt to develop a cost/benefit analysis of the incorporation of Landsat derived land use information into hydrologic modeling studies with the sparseness of existing case studies and the wide variation in the data and study circumstances encountered.

Findings for Future Studies

- A complete definition and analysis of the two land use approaches is presented which should aid decision makers in selecting one method for use in their work;
- For a complete evaluation of the application of one of the methodologies a potential user should not just look at the results of this study but should look at all the individual measures of effectiveness and their relationships to the users exact needs;
- For a given project the measures of effectiveness and their relative weights could be quite different than those presented in this study and should be evaluated more nearly on a case by case basis;
- For the Landsat methodology the cost to classify any portion of a satellite scene is close to being the same as classifying the whole scene. However, ground truth and verification costs would increase. Nevertheless, it would still be advantageous to do the whole scene and save the results for other potential users;
- If the user community is required to directly bear the costs of the operation of the Landsat system, the cost of obtaining land use data from satellite imagery will increase;

- The use of grid cell data bank types of data management systems will likely increase in the future and the Landsat methodology for land use classification is highly compatible with this system;
- The improved resolution of Landsat-D will improve and expand the use of satellite data in hydrologic studies and possibly environmental and economic studies;
- Development of different classification techniques than those commonly used now along with new enhancement procedures may improve land use classification of satellite data, thus making its use in hydrologic studies even more desirable;
- Potential long term users should consider that there is no guarantee that the satellite will last its expected life or that its subsequent replacement is inevitable;
- There appears to be a great untapped potential for use by agencies, in addition to the Corps of Engineers, of Landsat derived land use information in conjunction with grid cell based data management systems, particularly those involved in planning and hydrology;
- A large potential for the use of satellite imagery seems to exist in other facets of water resources management in addition to flood plain hydrology; and
- Additional data from other case studies should be collected and added to that in this report to further solidify the findings of this work and hopefully lead to even more detailed conclusions.

Subsequent sections of this report detail the various phases involved in the cost effectiveness analysis.