# Remote sensing applications for the southeastern Anatolian project

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# Remote sensing applications for the southeastern Anatolian project

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**Abstract:** The southeastern Anatolian development project, *Guneydogou Anadolu Projesi* (GAP), is one of the largest irrigation and hydroelectric power projects to be undertaken in Turkey. This integrated project consists of 13 subprojects located on the Euphrates and Tigris rivers. The target is the irrigation of 1.65 million ha and annual production of 26 billion kWh of energy.

A detailed soil survey of the area using remote sensing techniques is planned over the next 3 years. Preliminary studies in the GAP area and Çukurova region revealed the undeniable importance of this technique for agriculture. Cloud-free conditions favorable to satellite image recording in this arid region have largely contributed to the success of these studies. The bare land surfaces are also an advantage, specially for detailed and accurate computer-assisted soil mapping.

An area as large as the southeastern Anatolian development project needs reliable and detailed data for reorganizing agriculture in the area. Earlier remote sensing surveys have proved the utility of this technique for generating considerable digital information for large areas.

**Résumé**

*Applications de la télédétection dans le projet de développement de l'Anatolie du Sud-Est*

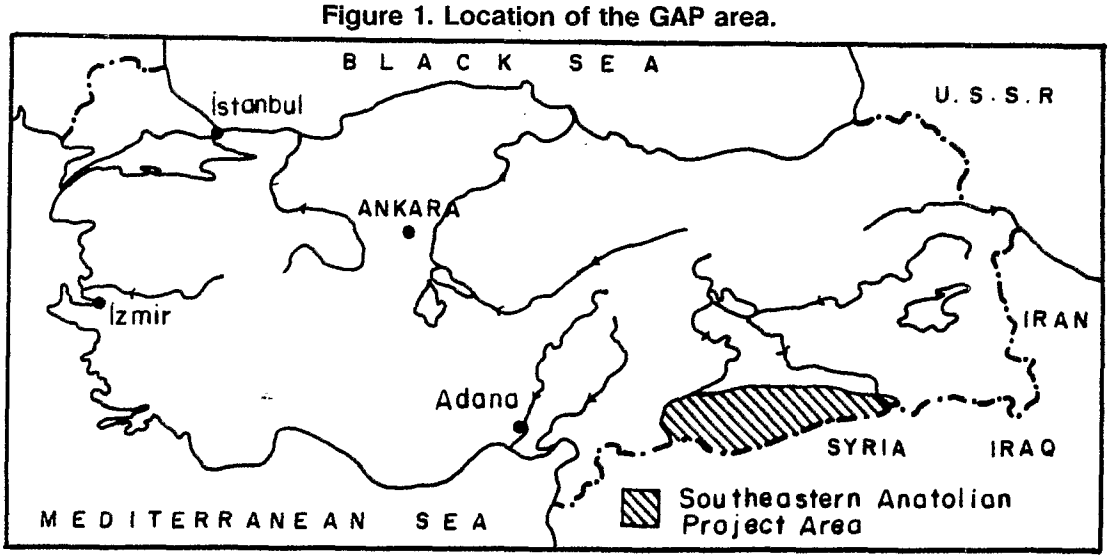
*Le projet de développement de l'Anatolie du Sud-Est est l'un des plus grands projets d'irrigation et de production d'énergie hydroélectrique qui ait été entrepris en Turquie. Ce projet intégré consiste en treize sous-projets situés sur les rivières Euphrate et Tigre. L'objectif est l'irrigation de 1,65 million d'hectares et la production annuelle de 26 milliards de kWh.*

*Un inventaire et une cartographie détaillés des sols doivent être faits dans cette zone pendant les trois prochaines années avec l'aide des techniques de télédétection. Les études préliminaires entreprises dans la région du projet et dans la région de Çukurova ont montré l'indéniable importance de cette technique pour l'agriculture. Le succès obtenu dans ces études est dû principalement au grand nombre de jours sans nuages favorables à l'enregistrement d'imagerie satellitaire de ces régions arides. L'absence de cultures en été dans ces régions présente l'avantage d'observer des sols nus, avantages appréciés des pédologues qui doivent produire avec l'aide de l'ordinateur des cartes précises et détaillées.*

*Une zone aussi grande que celle du projet de développement de l'Anatolie du Sud-Est a besoin de données fiables et détaillées pour la réorganisation de l'agriculture. Les résultats obtenus lors des études précédentes utilisant la télédétection ont prouvé la possibilité de produire des informations numériques sur de grandes surfaces.*

The southeastern Anatolian development project, *Guneydogou Anadolu Projesi* (GAP), is one of the largest irrigation and hydroelectric power projects to be undertaken in Turkey. The GAP area is 74 000 km² which is one-tenth of the total area and one-fourth of the irrigable area of Turkey (**Figure 1**). It covers six provinces situated on the fertile plains formed by the tributaries of the Euphrates and Tigris rivers.

**Figure 1. Location of the GAP area.**




The integrated project was developed between 1936 and 1960 as hydrological and land surveys. The feasibility studies of the 13 subprojects that make up the whole project area were prepared in 1970 (**Table 1**). These preliminary surveys and studies provided the groundwork for the vast southeastern Anatolian project. Construction of the subprojects will be completed within a period of 30 years.

**Table 1. The GAP projects.**

| Projects | Energy production (gWh/year) | Area to be irrigated (ha) |
|---|---|---|
| **Euphrates projects** | | |
| 1. Lower Euphrates | 8 245 | 706 208 |
| 2. Karakaya | 7 354 | |
| 3. Border Euphrates | 3 170 | |
| 4. Suruc-Baziki | 107 | 146 600 |
| 5. Göksu-Araban | | 82 685 |
| 6. Adiyaman-Kahta | 509 | 74 510 |
| 7. Gaziantep | | 89 000 |
| **Tigris projects** | | |
| 8. Dicle Kiralkizi | 444 | 126 080 |
| 9. Batman | 483 | 37 744 |
| 10. Batman Silvan | 670 | 213 000 |
| 11. Garzan | 315 | 60 000 |
| 12. Ilisu | 3 830 | |
| 13. Cizre | 1 000 | 121 000 |
| Total | 26 127 | 1 656 627 |

Massive energy production on completion of the project will greatly improve agriculture as well as the social structure. The main objective of the GAP project is to improve the economic status of the people in the area and to intensify the use of potential resources. **Table 2** shows current production in Turkey and the benefits to be gained from GAP for certain crops. Agricultural production in Turkey is expected to almost double in size as a result of this project.

**Table 2. Comparison of current and expected agricultural production in the GAP area.**

| Crop | Production (t) | | Percent increase after GAP |
|---|---|---|---|
| | Current | GAP (estimate) | |
| Cotton | 580 000 | 685 402 | 118 |
| Tobacco | 177 529 | 18 888 | 11 |
| Sugar beet | 14 308 375 | 4 098 895 | 29 |
| Oilseeds | 1 807 904 | 1 327 820 | 73 |
| Maize | 1 500 000 | 117 869 | 8 |
| Rice | 168 000 | 141 838 | 84 |
| Vegetables | 12 398 950 | 3 513 842 | 28 |
| Nuts | 23 000 | 66 458 | 289 |
| Fruits | 1 303 900 | 660 019 | 51 |

The aim of this paper is to present the **reconnaissance work** carried out for agricultural development and the water resource management in the GAP area and to briefly discuss the possibilities for the application of remote sensing techniques, giving examples from similar sites.

## I. – The GAP water resources system

The GAP water resources system comprises 13 subprojects, of which 7 are on the river Euphrates and 6 on the river Tigris. The irrigation and hydroelectric power generation components of the system include 15 dams and 18 power stations.

Following the completion of the project the total area to be irrigated — surface and ground water — is estimated at 1.65 million ha and annual energy production at 26 billion kWh. The energy target is equal to total energy production in Turkey in 1981 (Bayoglu, 1984). Total investment for the project according to present figures is approximately US$11 billion, which is almost equal to the total Turkish budget for 1987. Sixty percent of the investment is earmarked for irrigation and the remaining 40% for the reconstruction of power stations.

Two-thirds of the development potential is in the Euphrates subsystem and one-third in the Tigris subsystem (**Table 1**). The most important project of the Euphrates subsystem is located on the lower Euphrates; it comprises five subprojects: Urfa-Harran, Mardin-Ceylanpinar, Siverek-Hilvan, and Bozova irrigation and pumping irrigation subprojects; Atatürk dam. The other Euphrates projects are the Keban dam (completed in 1976) and Karakaya dam (1986).

## II. – Previous and future remote sensing studies

Since 1974, satellite data have been used in the University of Çukurova by soil scientists, agronomists, and physicists. Natural resources were studied by visual image interpretation and computer-assisted methods. The studies include soil mapping, and acreage and yield estimation for small grains and cotton.

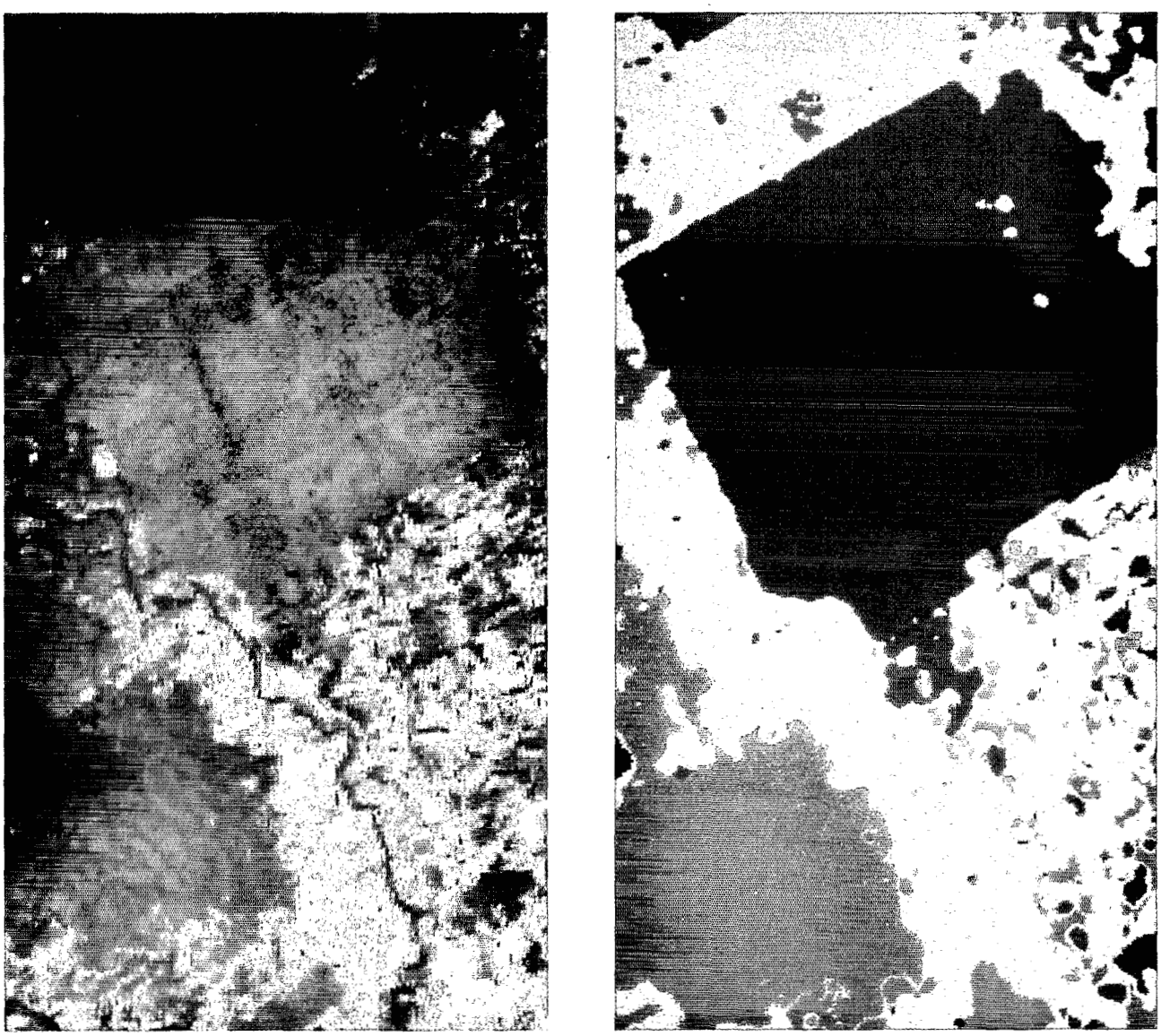
### Previous studies

● Landsat-3 MSS data and ground-based measurements with a portable radiometer were used to **determine soil characteristics and small-grain acreage** in the Ceylanpinar State Farm, one of the

largest in the world (**Figure 2**). Two different methods — maximum likelihood and vegetation index — were used to classify soils and small-grain fields. For yield estimation, it was observed that small-grain yields were related to soil structure and characteristics (Dinc et al., in press).

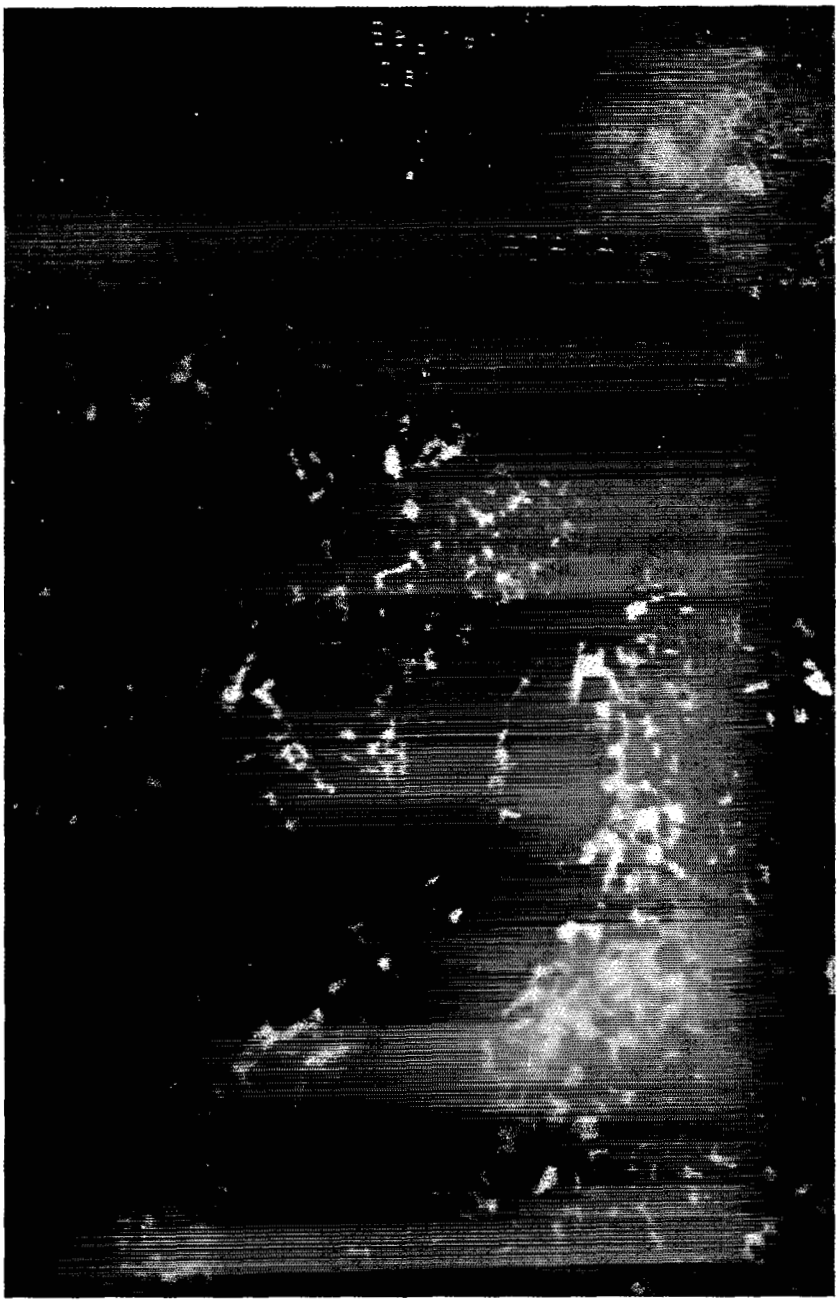
**Figure 2. Ceylanpinar State Farm.**
A small part seen as: (a) Landsat-3 MSS image in band 7
(b) classified image based on the vegetation index, where:
dark gray tones represent wheat crops; light gray, grass; and white-gray, bare soil.

(a) (b)



Landsat-5 TM data were used for detailed mapping at soil series level for an area covering 1 800 ha in the Çukurova region. Supervised classification revealed spectral separations for seven soil series in bands 5 and 7. It was concluded that February and March were the most suitable months for mapping similar Mediterranean alluvial soils by using satellite data. Comparison of the TM classified images with the previously compiled soil map of the region showed 80.6 % similarity. Subsequent ground truth verification showed that the TM classification was correct with a 90 % confidence level (Sari et al., in press).

**Figure 3. Classified image of the Çukurova region after the flood in April 1980.**
(darkest gray: water without sediment; lightest gray: water with highest sediment content)



● The Taurus mountains in southern Turkey receive considerable precipitation, mostly in the form of snow. In spring the snow melts and fills the Seyhan dam on the Seyhan river near Adana. Excess water (1 400 $m^3/s$) caused a major flood in 1980. The **flood area** was studied using Landsat-3 data (**Figure 3**). The use of satellite data for such work proved to be an easy, fast, and inexpensive way to obtain correct results (Dinc et al., 1982).

**Figure 4. Thermal image of the frost-affected areas in the Çukurova region on 8 March 1985.**
The cold and hot weather corridors can be clearly distinguished.
(dark gray: cold areas; medium and light gray: high-temperature areas)


● Another interesting study (Pestemalci et al., in press) was the determination of **frost-affected areas** in the Çukurova region by using Landsat-TM data (**Figure 4**). The frost damage observed through TM data

occurred in February and March 1985 and affected vegetation, especially citrus trees. Certain citrus-planted areas were not affected by frost due to their topographic situation. The cold weather corridors were also checked at level ground. The frost-affected citrus areas were determined and correlated with the Landsat results.

● Remotely sensed data were also used for detailed **soil mapping** of the Harran plain, which will be irrigated by 1992 (Dinc et al., 1986). A high degree of accuracy was obtained for the the soil-map legend and boundaries of different soil series.

**Future studies**

The remote sensing working group of the University of Çukurova has prepared a project for a **detailed soil map** (1:25 000, 1:50 000) of the GAP area using Landsat-TM and SPOT data. The project covers an area of 450 000 ha in the Mardin-Ceylanpinar plains.

The method that will be used for the detailed soil map of the GAP area was developed and applied to various small-scale model areas in the GAP area and Çukurova region. The method involves four steps. In the first step, the area covered with vegetation is removed from the satellite image by using a vegetation index method so that only bare soil is left in the satellite data. In step two, one of the statistical unsupervised classification methods, such as clustering, is used for soil classification. The third step comprises ground-based measurements to check the classified soil map. In this phase some more data need to be collected for unclassified or misclassified regions. The fourth step involves ground data input. An accurate soil map of the study area is generated by using one of the supervised classification methods.

● The remote sensing working group will also work on projects dealing with **annual discrimination of crop pattern** and **changes in land use** with the application of irrigation practices. Postirrigation yields of major field crops such as wheat and cotton will be estimated. **Seasonal soil drainage** and **soil salinity and alkalinity**, which are of utmost importance for irrigated high-altitude clayey tablelands, will be determined and monitored using satellite data.

## III. – Conclusion

The southeastern Anatolian project, GAP, is one of the largest development efforts undertaken at the lower reach of the Euphrates and Tigris rivers in Turkey. The total area of the region is about 74 000 km$^2$. The targets of the integrated project are irrigation of 1.65 million ha of land and annual production of 26 billion kWh of net energy. The region has an arid climate, with practically no precipitation between June and September. Its economy is largely based on agriculture. Dryland agricultural techniques are generally practiced. Due to the high development potential of the project area, modernization of agriculture is given a high priority. Production value is expected to increase ten- to twentyfold.

The detailed soil survey of this plain is scheduled to be completed within 3 years. This period is much shorter than that of conventional soil surveys to be undertaken in the area. Such detailed soil maps are the basic material for optimum land use planning.

Preliminary studies conducted in the GAP area and Çukurova region have indicated the importance of remotely sensed data for agriculture. The success of the preliminary studies in the GAP area can be attributed to the number of cloud-free days (average 280-310 days annually) and arid climatic conditions in the area. The bare land surface of summer fallow is also an advantage for accurate and detailed computer-assisted soil mapping. Large projects like GAP necessitate detailed basic data for reorganizing agriculture. Remote sensing data provide considerable digital information for large areas. Although existing reconnaissance data on soils and geology have been constantly updated and enhanced over the past decades, more detailed information on the GAP area is needed for successful reorganization of agriculture in the region.

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