SPACE TECHNOLOGY AND GEOGRAPHIC INFORMATION SYSTEMS APPLICATIONS IN ADB PROJECTS

ASIAN DEVELOPMENT BANK

ADB

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Abbreviations

ADB	Asian Development Bank
AFSIS	ASEAN Food Security Information System Project
ALIS	Agricultural Land Information System
ALOS	Advanced Land Observing Satellite
ASEAN	Association of Southeast Asian Nations
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BAS	Bureau of Agricultural Statistics
BWDB	Bangladesh Water Development Board
CAREC	Central Asia Regional Economic Cooperation
CASP	Core Agriculture Support Program
CEGIS	Center for Environmental and Geographic Information Services
CLUE	Conversion of Land-Use Change and its Effects
DEM	digital elevation model
DMCs	developing member countries
DONRE	Department of Environment and Natural Resources
DSM	digital surface model
GIS	geographic information systems
GISTDA	Geo-Informatics and Space Technology Development Agency
G-MIS	GIS-based municipal information systems
GMS	Great Mekong Subregion
GPS	Global Positioning System
GSMaP	Global Satellite Mapping of Precipitation
IRS	Indian Remote Sensing Satellite
IWRM	integrated water resource management
JAXA	Japan Aerospace Exploration Agency
JSM	Java Spatial Model
KBDI	Keetch Byram Drought Index
km	kilometer
Lao PDR	Lao People's Democratic Republic

LISS	Linear Imaging Self-Scanning
LST	land surface temperature
m	meter
mm	millimeter
MODIS	Moderate Resolution Imaging Spectrometer
MONRE	Ministry of Natural Resources and Environment
MTSAT	Multifunctional Transport Satellite
NHMS	National Hydro Meteorological Service
NREL	National Renewable Energy Laboratory
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PALSAR	Phased Array L-band Synthetic Aperture Radar
PRC	People's Republic of China
RDMS	Remote Sensing-Based Drought Monitoring System
RESTEC	Remote Sensing Technology Center of Japan
SAR	Synthetic Aperture Radar
SEBAL	Surface Energy Balance Algorithm for Land
ST	space technology
SUPARCO	Space and Upper Atmosphere Research Commission
WGA	Working Group on Agriculture
WARPO	Water Resources Planning Organization

Foreword

Today, space technology and geographic information systems (GIS) are no longer just fields of advanced technological development and scientific research, but they have become valuable tools to help development organizations achieve their missions. They can be applied to various development sectors of the Asian Development Bank (ADB) including agriculture, rural development, and food security; education; energy; environment; climate change; health; public management and governance (especially disaster risk management); transport; urban development; and water. They can improve the efficiency of ADB operations and effectively address issues in sustainable development in developing member countries (DMCs).

Based on this understanding, ADB has implemented many projects applying space technology and GIS since the 1990s. In July 2010, ADB finalized a letter of intent with the Japan Aerospace Exploration Agency (JAXA) to collaborate on disaster management, climate change mitigation and adaptation, forest monitoring, and water resource management using space technologies, mainly those involving remote sensing. The collaboration field was expanded to include agriculture and urban development in 2012. An increasing number of projects using these technologies have been implemented in recent years.

To promote more effective applications in the field of sustainable development, sharing best practices is very important. This report provides an overview of the space technology and GIS applications in ADB to date by introducing some of the past and ongoing ADB projects that have applied space technology and/or GIS. It includes information about how the technologies were applied, the service providers, and the cost for the application, so that practitioners including staff of development organizations and government staff in DMCs can easily apply similar technologies to their projects and/or daily operations.

We hope that this report proves useful to ADB staff, other development partners, and DMCs by sharing the information necessary to apply space technology and GIS to their projects and activities.

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Introduction to Space Technology

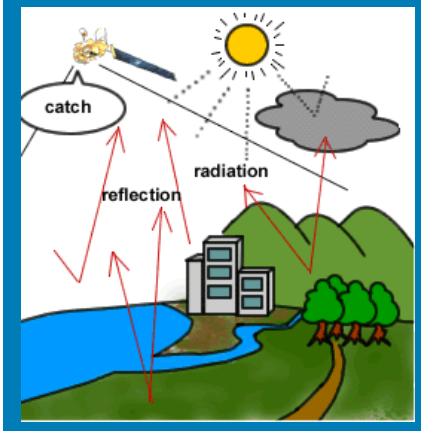
There are several types of space technology applications including (i) remote sensing, (ii) satellite navigation systems such as the Global Positioning System (GPS), and (iii) satellite communication systems. In this report, the main emphasis is on projects that rely on the results of remote sensing applications.

Remote sensing is a technique to observe the earth's surface or the atmosphere with cameras or sensors installed in satellites. Its advantages include

(i) the ability to record data for inaccessible or dangerous areas;
(ii) a comparatively low cost per unit of area;
(iii) wide, objective, frequent, and periodic data collection; and
(iv) the availability of historical data.

These advantages enable remote monitoring of project sites and cost-effective long-term periodic monitoring of the wide area necessary for development activities such as environmental monitoring and climate change impact assessment. Remote sensing is particularly effective in developing member countries (DMCs) that suffer from the lack of infrastructure for data acquisition. Table 1 shows typical applications in each sector in ADB.

Figure 1 Overview of Satellite Remote Sensing



Source: Japan Aerospace Exploration Agency. 2003. *Principles of Remote Sensing.* http://www.eorc.jaxa.jp/en/hatoyama/experience/rm_kiso/whats_remosen_e.html

Table 1 Typical Applications of Remote Sensing in Asian Development Bank Projects

Sector	Applications
Infrastructure	Satellite-based imagery, maps, land cover and/or land use maps in planning, monitoring, safeguard activities, etc.
Agriculture and food security	Satellite-based land cover and/or land use maps, crop yield estimation, cultivated area, vegetation index, evapotranspiration, soil moisture, precipitation, drought indices, etc.
Disaster risk management	Satellite-based rainfall data for flood forecasting, satellite-based drought indices for monitoring. Satellite-based disaster damage assessment (satellite imagery, inundation maps), disaster risk maps, etc.
Energy	Satellite-based solar irradiation maps, wind resource maps for solar and wind energy projects to identify suitable location, satellite night view map for understanding energy access.
Environment and climate change adaptation	Satellite-based imagery, impact area maps, land cover maps, forest and/or non-forest maps, water quality, river bank, and coastal change maps, etc. for environmental and/or climate change monitoring projects or environmental and social safeguard activities.
Urban development	Satellite-based urban mapping of infrastructure and buildings, land cover and land use mapping, digital elevation models, land subsidence mapping for urban planning, monitoring, and assessment.
Water resources management and irrigation	Satellite-based land cover maps, water body maps, water quality information, temperature and water level, evapotranspiration to evaluate water productivity, soil erosion analysis, precipitation, soil moisture, drought indices, etc.

1 Space Technology Applications in Asian Development Bank Projects

Table 2 List of Projects Applying Space Technology

Sector	Country	Project Title	Application
Climate change adaptation	Bangladesh	Strengthening the Resilience of the Water Sector in Khulna to Climate Change (TA 7197-BAN) (See page 25)	High-resolution satellite imagery as background for GIS analyses
Disaster management	Pakistan	Pakistan Floods (2010) Damage and Needs Assessment (TA 7579-PAK)	Satellite-based flood damage assessment
	Bangladesh, Philippines, Viet Nam	Applying Remote Sensing Technology in River Basin Management (TA 8074-REG)	Improvement of flood forecasting using satellite-based rainfall data
Energy	Uzbekistan	Solar Energy Development (TA 8008-UZB)	Satellite-based solar energy resource map
	Mongolia, Philippines, Sri Lanka	Quantum Leap in Wind Power Development in Asia and the Pacific (TA 7990-REG)	Satellite-based wind energy resource map
Environment	Bangladesh	Land Use Mapping of the Chittagong Hill Tracts Using Remote Sensing (TA 7481-BAN)	Satellite-based land coverage map and digital elevation model
Food security	Philippines	Improving Agricultural and Rural Statistics for Food Security (TA 8029-REG)	High-resolution satellite imagery for land classification for agricultural statistics
	Lao PDR, Philippines, Thailand, Viet Nam	Innovative Data Collection Methods for Agricultural and Rural Statistics (TA Proposed)	Rice crop cultivation mapping and yield estimation using satellite radar data
	Cambodia, PRC, Lao PDR, Myanmar, Thailand, Viet Nam	Accelerating the Implementation of the Core Agriculture Support Program (TA 6521-REG)	Satellite-based near real-time drought monitoring system
Urban Development	Nepal	Institutional Strengthening of Municipalities (TA 7355-NEP)	Satellite-based base map for urban development
Water resource management	Indonesia	Institutional Strengthening of Integrated Water Resources Management in the Six Cis River Basin Territories (TA 7189-INO)	Satellite-based land coverage maps for integrated water resource management
	Bangladesh	Jamuna-Meghna River Erosion Mitigation Project (Loan 1941-BAN)	River bank erosion monitoring using satellite imagery
	Viet Nam	Second Red River Basin Sector Project (Loan 1855-VIE)	Satellite-based drought monitoring
Infrastructure	PRC	Chongqing Urban-Rural Infrastructure Development Demonstration Project (TA 7108-PRC)	Satellite imagery application for environmental impact assessment

GIS = geographic information systems, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Pakistan Floods (2010) Damage and Needs Assessment

Project Title	Pakistan Floods (2010) Damage and Needs Assessment
Project Number	TA 7579-PAK
Country	Pakistan
Department/Division	Central and West Asia Department/Pakistan Resident Mission
Executing Agency	Ministry of Economic Affairs and Statistics
Sector/Subsector	Multisector/Multisector
Amount Approved	$220,000
Approval/Completion	19 August 2010/31 December 2010
Source	http://www.adb.org/projects/44356-012/main
Space Technology (ST) Application	Satellite-based flood damage assessment
ST Data	Satellite imagery and radar data
ST Cost	Not available
ST Service Providers	Satellite image analysis and GIS process; Space and Upper Atmosphere Research Commission of Pakistan (SUPARCO), Satellite data; Japan Aerospace Exploration Agency (JAXA)
Users	Damage Needs Assessment team

GIS = geographic information systems.

Context

Pakistan experienced extraordinary rainfall from mid-July to September 2010. According to the National Disaster Management Authority, the rains and floods have affected over 20 million people. In the wake of this extraordinary situation, the Government of Pakistan asked ADB and the World Bank to jointly lead the Damage Needs Assessment.

Contribution of Space Technology

The assessment team utilized remote-sensing-based damage validation, particularly in the housing sector, and to a limited extent in the agriculture and transport sectors. The team commissioned SUPARCO of Pakistan to produce independent validation data on the damage caused by the inundation. GIS and satellite imagery freely provided by Japan Aerospace Exploration Agency (JAXA) were used to map the extent of inundation and to estimate the detailed damage to housing, agriculture, and transportation facilities.

Results

The field coordinator's verification work for the reported damage was supported by the satellite-based inundation map. Damage estimates and reconstruction costs were subsequently updated and finalized.

Applying Remote Sensing Technology in River Basin Management

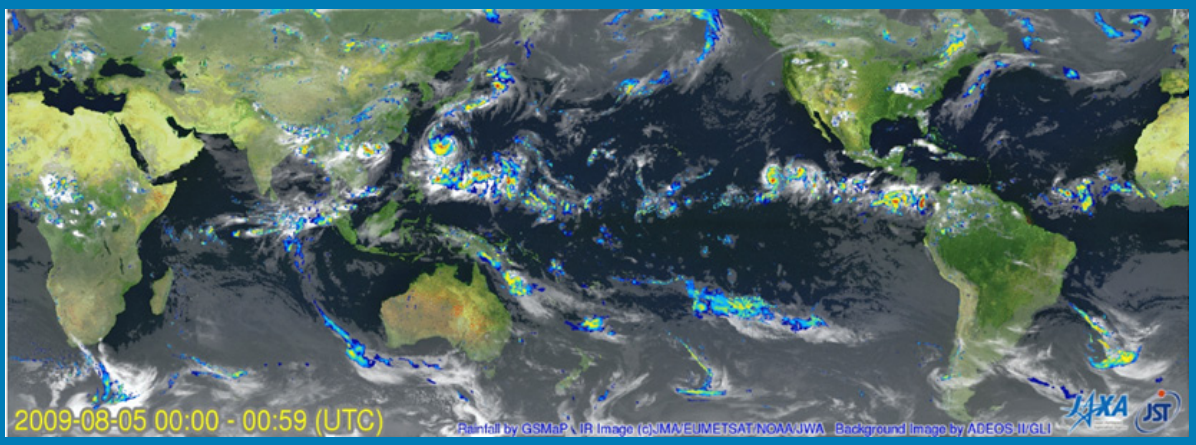
Project Title	Applying Remote Sensing Technology in River Basin Management
Project Number	TA 8074-REG
Country	Regional (Bangladesh, Philippines, Viet Nam)
Department/Division	Regional and Sustainable Development Department/Sustainable Infrastructure Division
Executing Agency	Asian Development Bank
Sector/Subsector	Agriculture and natural resources/Water-based natural resources management
Amount Approved	$2,000,000 (ADB), $648,440 (JAXA in-kind)
Approval/Completion	27 April 2012/31 December 2014 (TBD)
Source	http://www.adb.org/projects/44164-012/main/
ST/GIS Application	Improvement of flood forecasting using satellite-based rainfall data and study to apply a Digital Terrain Model to local flood model; web-GIS for flood forecasting information sharing
ST Data	Global Satellite Mapping of Precipitation (GSMaP) provided by JAXA and digital surface model (DSM) derived from the Advanced Land Observing Satellite (ALOS)
ST/GIS Cost	International consultant for 9 person-months to develop methodology and system to calibrate GSMaP and capacity development International consultant for 4 person-months to correct the ALOS DSM $200,000 to procure ALOS DSM National consultant for 4 person-months national consultant to develop web-based GIS in Bangladesh and Viet Nam
ST/GIS Service Providers	JAXA, PASCO Corporation (ALOS DSM), Remote Sensing Technology Center of Japan (GSMaP calibration), national individual consultants (web-based GIS)
Users	Bangladesh Water Development Board (BWDB), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), National Hydro Meteorological Service (NHMS) under Ministry of Natural Resources and Environment (MONRE) of Viet Nam

ADB = Asian Development Bank, GIS = geographic information systems, JAXA = Japan Aerospace Exploration Agency, ST = space technology, TBD = to be determined.

Context

Many countries in Asia and the Pacific have suffered from water-related disasters such as floods caused by typhoons and heavy rains. As one of the most powerful nonstructural measures to guard against water-related disasters, monitoring and warning systems have been implemented in Asia and the Pacific. However, there is still insufficient latency, frequency, and coverage of observation data; and inadequate dissemination of warnings to local communities. This technical assistance project is helping Bangladesh, the Philippines, and Viet Nam improve monitoring and warning systems on flood risk management at a reasonable cost and based on practical knowledge by applying space-based technology and information and communication technology. Target agencies are assisted with advisory services and financial support in formulating and implementing the following: (i) extending flood warning lead times by 1 day–2 days in the Jamuna River basin in Bangladesh by collecting precipitation data publicly available from satellites and ground observation systems, (ii) developing existing flood analysis models in the Red-Thai Bin River basin in Viet Nam by collecting satellite precipitation data, (iii) developing a system in the Cagayan River

Figure 2 Global Satellite Mapping of Precipitation



Source: Japan Aerospace Exploration Agency.

basin in the Philippines to provide satellite-based precipitation data and transfer it to the existing flood analysis model, and (iv) developing flood warning dissemination and disaster monitoring systems using web-based GIS and cellular phones in Bangladesh and Viet Nam. JAXA is collaborating with ADB in this project as the implementing agency, supporting project management and providing technical advice.

Contribution of Space Technology and Geographic Information Systems

GSMaP is an hourly global rainfall map in near real time, available 4 hours after observation with a 0.1 degree (about 10 kilometers [km]) grid over a global area (60N–60S), using the JAXA Global Rainfall Watch System. JAXA and the consultant team have been developing methodologies and systems to calibrate and validate GSMaP with ground rainfall data in the pilot area of each country. The calibrated GSMaP is used as input data for flood models in the target river basin for more effective and efficient flood forecasting. These models include the Integrated Flood Analysis System in the Philippines, which was developed by the International Centre for Water Hazard and Risk Management, and the Water and Energy Budget-Based Distributed Hydrological Model, developed by Professor T. Koike, University of Tokyo.

High-quality, satellite-based topographical information (digital elevation model [DEM] or digital surface model [DSM]) obtained from the Advanced Land Observing Satellite (ALOS) was used to study the effectiveness of its use for the local flood model to make an inundation map in the pilot area as an alternate source of geographic data to those obtained from spot survey. ALOS imagery and map data for the pilot area of the local flood model were used for the background layer of the web-based GIS developed under this technical assistance project.

Web-based GIS was also developed for flood warning information sharing in the pilot areas in Bangladesh and Viet Nam.

Results

The project is ongoing and the results of these applications will be available by the end of the project, which is planned for December 2014.

Solar Energy Development

Project Title	Solar Energy Development
Project Number	TA 8008-UZB
Country	Uzbekistan
Department	Central and West Asia Department/Energy Division
Executing Agency	Ministry of Finance
Sector/Subsector	Energy/Renewable energy
Amount Approved	$2,250,000
Approval/Completion	16 December 2011/September 2013
Source	http://www.adb.org/projects/45120-001/main
ST/GIS Application	Satellite-based solar energy resource map
ST Data	Direct Normal Irradiance, Global Horizontal Irradiance, and Diffuse Horizontal Irradiance
ST Cost	Not available
ST Service Providers	3TIER
Users	Scientific-Production Association on Solar Physics, Physical-Technical Institute, and Material Science Institute

GIS= geographic information systems, ST = space technology.

Context

The most promising source of renewable energy in Uzbekistan is solar energy. Despite its solar resource potential, a pool of solar energy experts, and abundant land on which to develop solar energy, limited exposure to modern solar technology and applications have prevented Uzbekistan from effectively harnessing its solar resources. In addition, it does not have sufficient reliable solar irradiance data for such development. This technical assistance project will contribute to the deployment of solar energy in Uzbekistan for both pilot and commercial solar energy projects.

Contribution of Space Technology and Geographic Information Systems

A satellite-based solar irradiance dataset and other space-based weather datasets were utilized for the project's models. The solar irradiance dataset is based on actual half-hourly visible satellite imagery observations via the broadband visible wavelength channel at a 2 arc-minute resolution. These data have been processed to create more than 10 years of hourly Global Horizontal Irradiance, Direct Normal Irradiance, *and* Diffuse Horizontal Irradiance data at a horizontal resolution of roughly 3 km. GIS analysis was conducted to identify suitable solar power sites.

Result

GIS analysis has resulted in the identification of suitable solar power sites in Uzbekistan. In the end there were six proposed suitable sites where meteorological stations could be installed. With the aid of space technology and GIS, the following were concluded: (i) More than 20 years of data is available from satellites with fair accuracy, (ii) the satellite data needs to be adjusted with high-precision measurements, and (iii) GIS analysis with ranking values on resource and infrastructure is a helpful tool for site selection.

Quantum Leap in Wind Power Development in Asia and the Pacific

Project Title	Quantum Leap in Wind Power Development in Asia and the Pacific
Project Number	TA 7990-REG
Country	Regional (Mongolia, Philippines, Sri Lanka)
Department/Division	Regional and Sustainable Development Department/Office of the Director General
Executing Agency	Asian Development Bank
Sector/Subsector	Energy/Renewable energy
Amount Approved	$2,000,000
Approval/Complete	9 December 2011/31 December 2014
Source	http://www.adb.org/projects/44489-012/main
ST Application	Satellite-based wind energy resource map
ST Data	Satellite-based terrain data and meteorological data
ST Cost	Not available
ST Service Providers	National Renewable Energy Laboratory of the United States (NREL), Earth Resource Observing Satellite Data Center
Users	Asia Clean Energy Forum

ST = space technology.

Context

This technical assistance project supports DMC governments to help them (i) draw up wind energy development road maps for better planning and facilitating public–private partnership, (ii) assess wind resources in target countries to reduce start-up time and manage resource risks, (iii) manage regional knowledge and build capacity to facilitate the transfer of knowledge and regional cooperation, (iv) prepare prefeasibility studies, and (v) develop business and financing models to make wind projects in participating countries more bankable.

Contribution of Space Technology

Wind resource maps showing the estimated wind power and equivalent wind speed developed by National Renewable Energy Laboratory (NREL) were used to understand wind resources in the target countries. These maps used inputs obtained from satellites, including gridded terrain data from Earth Resource Observing Satellite Data Center and meteorological data. The meteorological data sources include surface (land and open ocean) and upper-air data sets. These data were screened to select representative stations and data periods for use in the mapping system. The final meteorological inputs to the mapping system were vertical wind profiles, wind power roses (the percentage of total potential power from the wind by direction sector), and the open ocean wind power density.

Results

In early stages of the project, the consultants used existing satellite-based wind maps from the United States' NREL and others for selecting regions with potentially excellent wind speeds in pilot countries.

Land Use Mapping of the Chittagong Hill Tracts Using Remote Sensing

Project Title	Land Use Mapping of the Chittagong Hill Tracts Using Remote Sensing
Project Number	TA 7481-BAN
Country	Bangladesh
Department/Division	South Asia Department/Agriculture, Natural Resources and Social Services Division
Executing Agency	Center for Environmental and Geographic Information Services
Sector/Subsector	Agriculture and natural resources/Agriculture and rural sector development
Amount Approved	$75,000
Approval/Completion	23 December 2009/31 August 2011
Source	http://www.adb.org/projects/42248-022/main
ST Application	Satellite-based land coverage map and DEM preparation
ST Data	Terra ASTER satellite stereo images, Landsat 7 ETM+ images
ST Cost	$75,000
ST Service Providers	CEGIS in Bangladesh
Users	Bangladesh Water Development Board and others

ASTER = Advanced Spaceborne Thermal Emission and Reflection Radiometer, DEM = digital elevation model, ETM+ = Enhanced Thematic Mapper Plus, ST = space technology.

Context

The Chittagong Hill Tracts is a 13,000 km^2 isolated area in Bangladesh. The rapid decline in dense forest in this area has been directly associated with the depletion of water resources. During ADB's Study for Potential for Integrated Small-Scale Water Resources Development in in the Second Chittagong Hill Tracts Rural Development Project, the lack of topographic and resource mapping of the area became increasingly evident. This technical assistance project was undertaken to produce land use and topographic maps of Chittagong Hill Tracts using remote sensing to support the preparation of the Second Chittagong Hill Tracts Rural Development Project (TA7432-BAN, Loan2763-BAN), which will provide rural infrastructure.

Contribution of Space Technology

The land use and/or cover map was derived from orthorectified Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite images with 15 meter (m) image resolution. Stereo ASTER images were also used for DEM preparation with Leica Photogrammetry Suite.

Results

This study provided land use and topographic maps of the Chittagong Hill Tracts area that can provide the basis for a GIS database on natural resources, which will enhance the capacity of Chittagong Hill Tracts-specific institutions to better plan and monitor natural resources and development interventions. This topographic map is necessary for designing small-scale water resources infrastructure including hydrological analysis (flood estimation and water balance). Similarly, a comprehensive land use mapping of the area will aid in (i) understanding the land use patterns of the area, (ii) identifying vulnerable locations, (iii) planning development activities in a coordinated comprehensive manner with other development partners, (iv) locating roads, rivers, and/or water bodies in relation to human settlements, and (v) ascertaining infrastructure-based deprivation indices.

Improving Agricultural and Rural Statistics for Food Security

Project Title	Improving Agricultural and Rural Statistics for Food Security
Project Number	TA 8029-REG
Country	Regional (Afghanistan, Australia, Bangladesh, Bhutan, India, Indonesia, Iran, Japan, Maldives, Myanmar, Philippines, Sri Lanka, Thailand, and Viet Nam)
Department/Division	Economics and Research Department/Development Indicators and Policy Research Division
Executing Agency	Asian Development Bank
Sector/Subsector	Agriculture and natural resources/Agriculture and rural sector development
Amount Approved	$500,000
Approval/Completion	13 December 2011/31 May 2014
Source	http://www.adb.org/projects/45261-001/main
ST Application	High-resolution satellite imagery for land classification
ST Data	Google Earth satellite imagery
ST Cost	$35,000 to introduce the Agricultural Land Information System (ALIS)
ST Service Providers	Association of Southeast Asian Nations (ASEAN) Food Security Information System Project (AFSIS)
Users	Bureau of Agricultural Statistics (BAS) of the Philippines

ST = space technology.

Context

This technical assistance project assisted the Bureau of Agricultural Statistics (BAS) of the Philippines in implementing the Agricultural Land Information System (ALIS), which was developed by ASEAN Food Security Information System Project (AFSIS). ALIS is a tool for an area sample survey method using personal computers that estimates agricultural land area and enables area sampling with minimal labor and low budgets. The agency responsible for the survey can make the framework, design the survey scale according to target accuracy, extract samples, make the survey sheet, and estimate the statistical area data, using ALIS.

Contribution of Space Technology

ALIS uses the "master sample method" to save on operation work. The master sample method is one of the statistical sample design methods that reduces the framework maintenance. Under this method, the master sample meshes are extracted from the original meshes (first sampling) and this gives framework information (calculated area of agricultural land by tracing its border line) to these extracted master sample meshes, and then extracts survey sample meshes (second sampling) from these master sample meshes. Google Earth images are used as background imagery in ALIS for making the meshes and inputting the results of field surveys.

Results

ALIS was installed at BAS and a capacity development program was provided by the experts of AFSIS. The pilot study to use ALIS has been conducted by BAS in some pilot provinces in the Philippines in 2013.

Innovative Data Collection Methods for Agricultural and Rural Statistics

Project Title	Innovative Data Collection Methods for Agricultural and Rural Statistics
Project Number	TA 8369-REG
Country	Regional (Lao People's Democratic Republic [PDR], Philippines, Thailand, and Viet Nam)
Department	Economics and Research Department/Development Indicators and Policy Research Division
Executing Agency	Asian Development Bank
Sector/Subsector	Agriculture and natural resources/Agriculture and rural sector development
Amount Approved	$2,000,000 (ADB), $375,000 (JAXA in-kind)
Approval/Completion	20 May 2013/May 2016 (TBD)
Source	http://www.adb.org/projects/46399-001/main
ST Application	Rice crop cultivation mapping and yield estimation using satellite radar data
ST Data	Synthetic Aperture Radar data and other satellite-based data
ST Cost	$2,000,000 (ADB), $375,000 (JAXA in-kind)
ST Service Providers	JAXA, Geo-Informatics and Space Technology Development Agency, remote sensing firm (TBD)
Users	Center for Statistics and Information in Lao PDR, Bureau of Agricultural Statistics in the Philippines; Office of Agricultural Economics and Geo-Informatics and Space Technology Development Agency in Thailand, Center for Informatics and Statistics in Viet Nam

ADB = Asian Development Bank, JAXA = Japan Aerospace Exploration Agency, ST = space technology, TBD = to be determined.

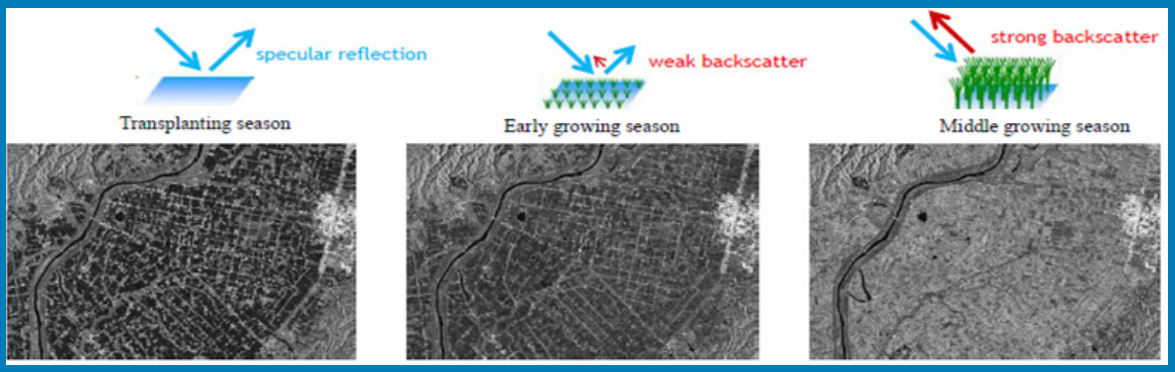
Context

Timely and reliable statistics of crop production and areas are important in monitoring government development plans and in mitigating the effects of extreme weather and climate change. These statistics are usually compiled through either administrative reporting systems or household surveys. A closer look at the data compilation in many countries reveals that crop production and other agricultural statistics are collected via administrative reporting systems, which are usually biased and unreliable. While this data collection approach is inexpensive, research has shown that is prone to large measurement errors.

This technical assistance project was conceptualized to promote the use of space-based technology in formulating and monitoring food security policies. The use of space-based technology produces reliable and timely measurements for estimating crop areas and forecasting production. The four pilot countries—Lao PDR, the Philippines, Thailand, and Viet Nam—were chosen because of the substantial contribution of the agriculture sector to their economies and the large proportion of their population that is still employed in agriculture.

The project consists of three major activities: (i) the development of customized software applications and methodology to estimate paddy rice cultivation area and crop production based on satellite data and in-situ data obtained through crop cutting experiments at a provincial level for four pilot countries, (ii) the training of counterpart staff in the four pilot countries, and (iii) the development of an online training program on the use of satellite data for agricultural and rural statistics.

Figure 3 Radar Signal Reflection

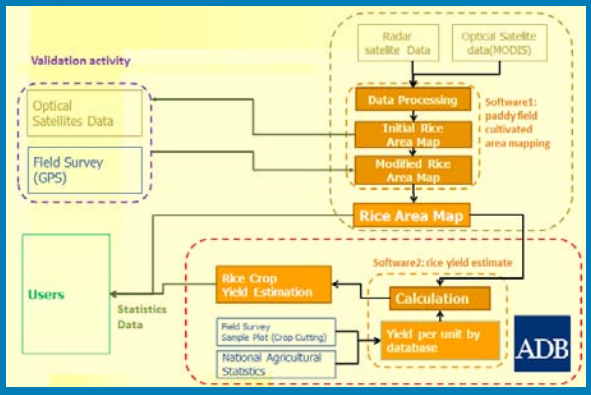


Source: Japan Aerospace Exploration Agency.

Contribution of Space Technology

First, paddy fields are detected and mapped using satellite radar data from multiple seasons. Because radar's active radio signal penetrates clouds, it is useful for obtaining data in regions with frequent cloud coverage during the rainy season. Before rice is planted, the surface of the rice field reflects the radar signal back like a mirror, and no signals returns to the sensor. In this situation, the radar imagery looks relatively dark. Once the rice begins to grow, however, the radar imagery looks relatively bright because the signal is scattered by the rice plants and returns to the sensors. By superimposing images taken before planting and after growth, cultivated areas of rice fields can be determined based on where the brightness of the signal has changed. Figure 3 shows Radar Signal Reflection for rice growth.

Figure 4 Overview of Project Components



GPS = Global Positioning System, MODIS = Moderate Resolution Imaging Spectrometer.
Source: Asian Development Bank. Innovative Data Collection Methods for Agricultural and Rural Statistics.

Optical satellite imagery with higher resolution is used for validation of the paddy rice cultivation area maps that have been developed using radar satellite data. By integrating information about rice production per unit obtained from sample crop cuttings and other statistical information with the cultivation area maps, rice crop production information is obtained. In order to make the system operate in a sustainable manner, this system applies satellite radar data in Scan Synthetic Aperture Radar (SAR) mode with relatively low spatial resolution based on a 100 m grid and wider coverage. The target rice crop production estimation is at the provincial level.

Results

This technical assistance project is ongoing and the results of these applications in pilot provinces in each country will be available by the end of the project, which is planned for May 2015.

Accelerating the Implementation of the Core Agriculture Support Program

Project Title	Accelerating the Implementation of the Core Agriculture Support Program
Project Number	TA 6521-REG
Country	Regional (Cambodia, People's Republic of China [PRC], Lao PDR, Myanmar, Thailand, Viet Nam)
Department/Division	Southeast Asia Department/Environment, Natural Resources and Agriculture Division
Executing Agency	Asian Development Bank
Sector/Subsector	Agriculture and natural resource/Agricultural production and markets
Amount Approved	$1,500,000 (ADB), $500,000 (PRC Regional Cooperation and Poverty Reduction Fund), $250,000 (in-kind contribution from participating countries)
Approval/Completion	23 December 2008/December 2015 (TBD)
Source	http://www.adb.org/projects/39542-012/main
ST Application	Satellite-based near real time drought monitoring system
ST Data	Multifunctional Transport Satellite (MTSAT)–Land Surface Temperature (LST)/Japan Aerospace Exploration Agency (JAXA)'s Global Satellite Mapping (GSMaP)
ST Cost	$120,000 (3 person-months international consultant plus training program)
ST Service Providers	Individual consultant from University of Tokyo, JAXA
Users	Policy makers of regional food security cooperation in Greater Mekong Subregion countries

Asian Development Bank, Lao PDR = Lao People's Democratic Republic, ST = space technology, TBD = to be determined.

Context

The Great Mekong Subregion (GMS) Core Agriculture Support Program (CASP) endorsed by the GMS Agriculture Ministers' Meeting in 2007 outlines the key objectives, program components, and indicative projects for subregional cooperation to be pursued by the Working Group on Agriculture (WGA). The Strategic Framework for Subregional Cooperation in Agriculture identified a number of issues and challenges regarding GMS cooperation in agriculture. There is a need to intensify efforts under the CASP to help address emerging global concerns, including climate change, rising food prices, water security, and rising rural energy demand. This technical assistance project has five main outputs: (i) implementation of the strategy for biotechnology and biosafety initiated, (ii) agriculture information and network service development and use promoted, (iii) rural renewable energy development strategy supported, (iv) food security and cross-border agriculture trade strategies developed, and (v) WGA Secretariat strengthened. In order to support component 2, it was agreed that the application of space-based technology for regional drought monitoring will be introduced with the support of JAXA in the implementation of CASP.

Contribution of Space Technology

The key activities of the technical assistance component for satellite-based drought monitoring are: (i) development of a sustainable satellite-based drought monitoring and warning system in the GMS; (ii) identification of drought vulnerable areas in the GMS with the developed system; (iii) development of methodology of cost–benefit analysis for an economic loss due to droughts in the GMS with the developed system; and (iv) development of the capacity of policy makers and data providers in the GMS for applying space-based technology for drought management.

The consultant developed the system that provides near-real-time satellite-based drought indices and provincial level drought warning information for policy makers. The drought index used in the system is Keetch Byram Drought Index, which is a meteorological drought index based on rainfall deficit, based on satellite rainfall data GSMaP product. This index has spatial resolution of 10 km and is daily updated. It is freely available from the University of Tokyo. This system automatically collects the indices from the University of Tokyo website and adjusts them for the use in the GMS. It also calculates the provincial level drought warning information based on the indices and warning thresholds. The index and warning information will be displayed on a webpage and linked to the GMS-Agriculture Information Network (AIN) website (http://www.gms-ain.org/). This system ensures its sustainability by using freely available satellite data and drought index obtained from satellites and automatic data processing by software. Once the system is developed by the consultant and installed on a server, it automatically processes and displays data, and does not require any human resources for operation.

Results

The developed web-based GIS system showing the satellite-based drought index and provincial level drought warning information in GMS was linked to the GMS-Agriculture Information Network website. Drought risk maps and cost–benefit analyses developed using the system were made available. A capacity development program for both policy makers and technicians in relevant agencies to apply the developed system was conducted. This has increased the capacity of CASP and participating countries to apply satellite-based regional drought monitoring, warning systems, and relevant information.

Institutional Strengthening of Municipalities

Project Title	Institutional Strengthening of Municipalities
Project Number	TA 7355-NEP
Country	Nepal
Department	South Asia Department/Urban Development and Water Division
Executing Agency	Ministry of Physical Planning and Works
Sector/Subsector	Water supply and other municipal infrastructure and services/Urban sector development
Amount Approved	$1,000,000
Approval/Completion	24 September 2009/11 November 2011
Source	http://www.adb.org/projects/42162-012/main
ST/GIS Application	Satellite-based base map and GIS application for urban management
ST Data	High-resolution satellite imagery
ST/GIS Cost	$21,738 (High-resolution satellite imagery)
ST Service Providers	SkyNepal Ltd.
Users	Local government unit of Nepal

GIS = geographic information system, ST = space technology.

Context

The municipalities and emerging towns of Nepal have developed haphazardly in the absence of stringent policy on regulating and managing their growth. The unplanned growth has created a number of problems such as deficiencies in basic urban services, lack of sanitation and solid waste management systems, environmental degradation, and encroachment of settlements on public lands, forests, and rivers. Additionally, the unprecedented rise of urban land price has encouraged land speculation and led to the indiscriminate subdivision of agricultural land and urban sprawl.

Many municipalities still lack proper base maps. Although the participating municipalities have or are developing basic digital base maps, there is no software to run the GIS and only very limited information and data are available in the GIS. Together with a rapid urbanization trend, there is a strong need to develop and/or update large-scale GIS-based urban maps with an adequate socioeconomic database. These maps will bring multiple benefits that can be used for better urban planning, project planning, tax information base, and public works engineering purposes.

As one of six expected outputs of the technical assistance project, GIS-based urban maps used for taxation and urban services will be delivered. This component's main outputs will include (i) GIS-based urban maps used to support taxation and urban service delivery that are integrated into functional GIS-based municipal information systems (G-MIS) in the target municipality, and (ii) enhanced staff skills in the use of GIS-based urban mapping technology. The component's main deliverables include (i) databases populated by socioeconomic survey data in specified formats (including digital pictures of surveyed properties), (ii) digital base maps in desired scales (1:2,500–1:5,000) integrated into the G-MIS, and (iii) relevant technical and user manuals.

Contribution of Space Technology and Geographic Information Systems

Satellite-based urban maps (1:2,500 and 1:5,000) using high-resolution satellite imagery will be made for GIS basic data that can be used to strengthen operations in municipalities. GIS allows a nonspatial and spatially connected database of any geographical area, which is crucial in planning, monitoring, and decision making. Information in the maps will include administrative boundaries, topographic features such as contour lines and land use, transportation infrastructure, utilities infrastructure, various buildings, cadastral data, and socioeconomic data. Figure 5 shows a combined display of a digital topographic map and a satellite image, which are available through the G-MIS.

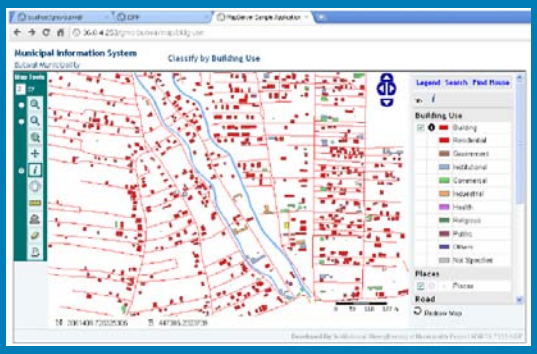
Results

Once satellite-based urban maps are established, they will be used for taxation and urban service delivery. This output is intended to strengthen urban planning by assisting participating municipalities in developing an effective GIS-based municipal information system. The GIS-based map will also be used to establish an effective house and street addressing system. The system will link the GIS with the property and business taxation system of the municipality and will be the basis to update the real estate asset inventory of each municipality. Figures 6 and 7 show a map query and visualization by building use and by building record, repectively.

Figure 5 Municipal Information System 1

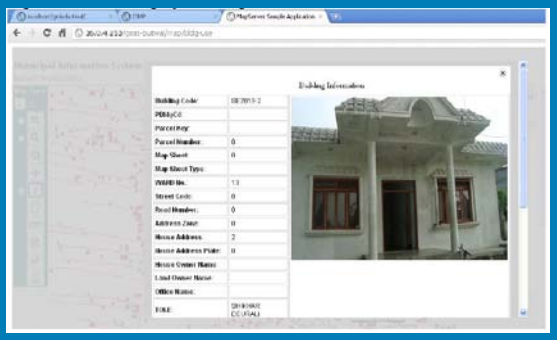
Source: Asian Development Bank. Institutional Strengthening of Municipalities. http://www.adb.org/sites/default/files/projdocs/2013/42162-012-nep-tacr-01.pdf#page=71

Figure 6 Municipal Information System 2



Source: Asian Development Bank. Institutional Strengthening of Municipalities. http://www.adb.org/sites/default/files/projdocs/2013/42162-012-nep-tacr-01.pdf#page=73

Figure 7 Municipal Information System 3



Source: Asian Development Bank. Institutional Strengthening of Municipalities. http://www.adb.org/sites/default/files/projdocs/2013/42162-012-nep-tacr-01.pdf#page=74

Institutional Strengthening of Integrated Water Resource Management in the Six Cis River Basin Territories

Project Title	Institutional Strengthening of Integrated Water Resources Management in the Six Cis River Basin Territories
Project Number	TA 7189-INO
Country	Indonesia
Department/Division	Southeast Asia Department/Environment, Natural Resources & Agriculture Division
Executing Agency	Directorate General of Water Resources of the Ministry of Public Works
Sector/Subsector	Water supply and other municipal infrastructure and services/ Urban sector development
Amount Approved	$900,000
Approval Date	24 September 2009/11 November 2011
Source	http://www.adb.org/projects/44352-012/main
ST Application	Satellite-based land coverage maps for integrated water resource management
ST Data	The Phased Array L-band Synthetic Aperture Radar (PALSAR) instrument onboard the Advanced Land Observing Satellite (ALOS)
ST Cost	Not available (Free PALSAR data provision by JAXA)
ST Service Providers	JAXA, Applied Geosolutions
Users	Institutional Strengthening of Integrated Water Resources Management in the Six Cis River Basin Territories Project

ST = space technology.
Note: "Six Cis" refers to the following six rivers: Citarum, Ciliwung, Cisadane, Cidanau, Ciujung, and Cidurian.

Context

The river basin territory made up of six rivers (Citarum, Ciliwung, Cisadane, Cidanau, Ciujung, and Cidurian) commonly known as the Six Cis, is about 20,000 km^2. It faces daunting challenges triggered by rapid urbanization with potential negative impacts on the water resource sector if not properly addressed. The rapid urbanization of the greater Jakarta and Bandung metropolitan areas is causing severe watershed degradation due to increased wasteload emission and deteriorating water quality, increased urban areas and loss of agricultural and irrigated paddy areas, decreased local food supplies, increased flooding, reduced infiltration to ground water, increased subsidence, and so forth.

In order to promote institutional strengthening of integrated water resources management in the six Cis river basin territory, a subcomponent for spatial planning was included. The main objective of the subcomponent was to provide the integrated water resources management (IWRM) planning process in other subcomponents with "internally consistent quantitative spatial planning outputs" based on the Java Spatial Model (JSM). Projections for population growth in the whole of Java are straightforward, but projections of growth at the *kabupaten* (district) scale and in each village and related land use are more complicated. A village is the smallest administrative unit in Indonesia and can be part of a rural area or an urban area. The JSM was used to provide spatial projections of population and associated land use changes for all villages on the island of Java, based on the overall population projection for Java and the economic growth projection by province. One of the tasks in the Strategic Spatial Planning subcomponent was the preparation of an up-to-date land use map for 2010, based on remote sensing data as an aid in calibrating and setting up the JSM.

Contribution of Space Technology

Through cooperation with JAXA, remote sensing images were made available from the Advanced Land Observation Satellite (ALOS). A major obstacle in preparing a 2010 land use map, based on 2010 remote sensing data, was that the year 2010 was cloudy, including the dry season. Cloud cover in tropical regions in general is problematic for optical sensors and can often limit the availability of systematic optical satellite platforms. Therefore, an alternative approach to the remote sensing task was required. The use of radar remote sensing specifically for rice and urban mapping was determined as the best option. A distinct advantage of radar relative to optical sensors is the ability to penetrate vegetation canopies, a direct sensitivity to water and urban structures, and the capacity for observation in all weather conditions. The Phased Array L-band Synthetic Aperture Radar (PALSAR) instrument onboard the ALOS was one such platform, with a mission to provide regional and operational microwave data collection. By using and interpreting the ALOS PALSAR images, it was possible to determine the most important land uses for the Java spatial model: urban areas, forest areas, and irrigated paddy areas. And as an added bonus, the radar band allowed detection of inundated rice paddies. With fine-beam repeat cycles of 4–5 times per year, the mapping of rice paddy inundation and hence cropping intensity was feasible. This spatial information was a useful metric for determining associated water demands and biogeochemistry.

Results

A Satellite-Based Land Use and Cover map around Jakarta was developed. The land use and land cover map had more than 85% overall accuracy and kappa scores using ground truth field photos. Correlations of urban and rice paddy areas between the PALSAR derived remote sensing maps and JSM model maps were strong at the *kabupaten* level (R^2:0.79 and R^2:0.97, respectively). Some variability at the village scale was found due to differences between land "use" and land "cover" as recognized between the PALSAR and JSM maps, which required interpretation for the project application. Overall the project found the advantages of PALSAR very useful for mapping land use and land cover, identifying paddy hydroperiod, and calibrating the JSM framework. In this study the cost effectiveness of the PALSAR approach was very efficient due to fact that ground truth data and the interpretation software had already been prepared in a previous study on rice greenhouse gas emission in that area. The cost of the interpretation of the PALSAR data was therefore only about $1.20 per km^2. The PALSAR images were provided for free under the ADB-JAXA cooperation, but the cost for four multi-temporal images would normally be around $0.50 per km^2. The amount of time needed for interpretation of the data was about 10 weeks.

Jamuna–Meghna River Erosion Mitigation Project

Project Title	Jamuna–Meghna River Erosion Mitigation Project
Project Number	Loan 1941-BAN
Country	Bangladesh
Department/Division	South Asia Department/Environment, Natural Resources & Agriculture Division
Executing Agency	Bangladesh Water Development Board (BWDB)
Sector/Subsector	Agriculture and natural resources/Water-based natural resources management
Amount Approved	$42,200,000
Approval/Completion	25 November 2002/5 October 2011
Source	http://www.adb.org/projects/34038-013/main
ST Application	River bank erosion monitoring using satellite imagery
ST Data	Indian Remote Sensing Satellite (IRS) linear imaging self-scanning (LISS), panchromatic (6 m grid), multispectral (24 m grid)
ST Cost	$20,000 (estimate)
ST Service Providers	Center for Environmental and Geographic Information Service (CEGIS) in Bangladesh
Users	BWDB projects, Water Resources Planning Organization (WARPO) projects

ST = space technology.

Context

Riverbank erosion is one of the major natural disasters in Bangladesh. It causes untold misery to thousands of people every year who live along the banks of the rivers of Bangladesh. To date, erosion alone has rendered millions homeless and has become a major social hazard. Most slum dwellers in the large urban and metropolitan towns and cities are victims of riverbank erosion.

Protection against riverbank erosion through structural interventions is very costly. Along with structural measures, less costly nonstructural measures, such as erosion prediction, can be used to reduce the risk of riverbank erosion for the people.

Since 2002, monitoring and predictions of morphological changes, initially for the Jamuna River and followed by those for the Ganges and the Padma, have been regularly made available to national level stakeholders. Evaluation of the predictions for the last few years shows a reasonably good match with the occurrences. The Jamuna-Meghna River Erosion Mitigation Project provided funds for the monitoring and predicting bank erosion along Jamuna, the Ganges, and the Padma.

Contribution of Space Technology

Satellite imagery was used for monitoring and predicting riverbank erosion.

For monitoring erosion, multi-spectral satellite images, Indian Remote Sensing Satellite linear imaging self-scanning (IRS LISS) of the dry season of 2009 and of the dry season of 2010 have been used. The resolution of these images is 24 m. The Indian Remote Sensing Satellite LISS images of 2010 have been used for predicting riverbank erosion. The single-band Indian Remote Sensing Satellite panchromatic images

(6 m resolution) are used as the primary source for some base information on roads, embankments, and settlements. More base information on the location of educational institutions, health centers, *hat-bazars (market)*, launch and/or ferry *ghats* (terminals), etc. have been incorporated and are regularly updated through field visits to both banks of the Jamuna and the Padma. Additionally base information of the Ganges has been prepared in this year. Table 3 lists the images used in the analysis.

Table 3 Satellite Images Used to Monitor and Predict Erosion and Morphological Changes

River name	Image type	Resolution
Jamuna	Multi-spectral	24 m x 24 m
Ganges		
Padma		
Jamuna, Ganges, and Padma	Panchromatic	6 m x 6 m

For predicting erosion, an empirical approach based on dry season satellite images was employed as the best and most cost-effective method with the available limited resources among various ways such as physical modeling and numerical modeling. By analyzing high-quality long-time series images, CEGIS has developed methodology and tools for predicting bank erosion and morphological changes of the Jamuna, the Ganges, and the Padma. Over the past several years, these methods of predicting morphological change and bank erosion have been successfully applied in a number of BWDB and WARPO projects.

Results

Two reports—Erosion Monitoring Report – 2009, which includes district-wide accounts of bank erosion and accretion along the rivers, and Prediction of River Bank Erosion – 2010, which includes district-wide predicted erosion—were developed. They will be used in various ways by national organizations such as BWDB for planning and maintaining their flood embankment, irrigation, and bank protection structures, by WARPO for national-level planning, by the Disaster Management Bureau for planning and implementing their response to erosion-affected people, by the Directorate of Relief and Rehabilitation for their activities in designing and planning relief and rehabilitation activities, and by the Local Government Engineering Department for maintaining and planning their road network.

Second Red River Basin Sector Project

Project Title	Second Red River Basin Sector Project
Project Number	Loan 1855-VIE
Country	Viet Nam
Department/Division	Southeast Asia Department/Environment, Natural Resources and Agriculture Division
Executing Agency	Ministry of Agriculture and Rural Development
Sector/Subsector	Agriculture and natural resources/Water-based natural resources management
Amount Approved	$70,000,000
Approval/Completion	27 June 2002/14 February 2011
Source	http://www.adb.org/projects/30292-013/main
ST Application	Satellite-based drought monitoring
ST Data	Moderate Resolution Imaging Spectrometer (MODIS) data
ST Cost	Not available
ST Service Providers	Water Watch - Surface Energy Balance Algorithm for Land (SEBAL) application
Users	Project officers, Policy makers

ST = space technology.

Context

The Red River is formed by the confluence of the Da, Thao, and Lo rivers just upstream of Ha Noi. The basin's population is 24 million, of whom 17 million live in the delta, making it one of the more densely populated areas in Asia. The Red River basin has a monsoon climate with pronounced wet and dry seasons. Rice is the main crop and intensive production relies on a combination of gravity and pumping from both irrigation and drainage canals. Floods and droughts are a major problem in the Red River basin. Serious water shortages were experienced in the dry seasons of 2004 and 2005, and the stress on the water system is likely to increase in the near future due to higher agricultural, domestic, and industrial water demands.

The Second Red River Basin Sector Project aimed to improve agriculture performance of poorer communities. The Cau sub-basin was selected to develop the participative integrated water resource management (IWRM) process to implement better drought management. A study was made for a pilot project within this project to evaluate and test the added value for remote sensing techniques on (i) quantifying drought and (ii) determining water productivity of rice systems. The advanced Surface Energy Balance Algorithm for Land (SEBAL) technique was used for the development of a Remote Sensing-Based Drought Monitoring System within the IWRM framework of the Cau sub-basin.

Contribution of Space Technology

The SEBAL was applied in conjunction with NASA's Moderate Resolution Imaging Spectrometer (MODIS) data aboard the Aqua satellite and routinely measured meteorological data to prepare an analysis of the extent and severity of drought in the Cau sub-basin and the Red River basin.

For each MODIS pixel (1 km resolution) the following hydrological variables were quantified:

(i) actual evapotranspiration,
(ii) potential evapotranspiration,
(iii) soil moisture, and
(iv) biomass production.

These distributed hydrological variables will be used to compute a composite water stress index. With these data, current water balances for the different sub areas of the Cau sub-basin can also be evaluated.

Results

The remote sensing drought analysis resulted in the following conclusions:

(i) the Cau sub-basin is drier than other irrigated areas in the delta;
(ii) the majority of the irrigated areas have a real water deficit of 50 millimeter (mm), which implies a very mild stress only;
(iii) water shortages in irrigation systems occur mainly in the central-west and northern part of the Cau sub-basin;
(iv) although upland forest systems have real water deficits of 100 mm–200 mm, biomass production is not affected, which is possibly related to ecosystem adaptation;
(v) the Cau sub-basin is not exposed to any systematic physical land degradation. To the contrary, fractional vegetation cover in both the wet and dry season has increased by 4% over the last 23 years.

Chongqing Urban-Rural Infrastructure Development Demonstration Project

Project Title	Chongqing Urban-Rural Infrastructure Development Demonstration Project
Project Number	TA 7108-PRC
Country	People's Republic of China
Department	East Asia Department/Urban and Social Sectors Division
Executing Agency	Chongqing Municipal Government
Sector/Subsector	Water supply and other municipal infrastructure and services/ Urban sector development
Amount Approved	$1,000,000
Approval Date	28 December 2009/31 December 2015
Source	http://www.adb.org/projects/42012-012/main
ST Application	Satellite imagery application for environmental impact assessment
ST Data	Not available
ST Cost	Not available
ST Service Providers	AECOM Asia Co. Ltd.
Users	Chongqing Municipal Road Bureau, Ministry of Water Resources

ST = space technology.

Context

This project strengthens urban–rural linkages and provides a highly replicable demonstration model for small-scale urban–rural roads and water supply development in poor districts and counties. In Chongqing's poorer districts and counties, poor road conditions severely restrict all-weather access for local communities within and between towns, while the lack of safe and reliable water supplies threatens public health and inhibits economic growth in rural areas. The strategy of urban–rural integrated infrastructure development will adopt a mode of development and urban expansion that considers the availability and responsible management of the natural resources of Chongqing.

Contribution of Space Technology and Results

Through an environmental impact assessment, estimates of the loss of nonagricultural and natural land were realized using satellite imagery with feasibility study reports and field reconnaissance. The loss of wasteland, conversion land, and shrubland under road and water supply infrastructure was estimated at about 92.83 hectares and the loss of community forest land was estimated at about 21.82 hectares.

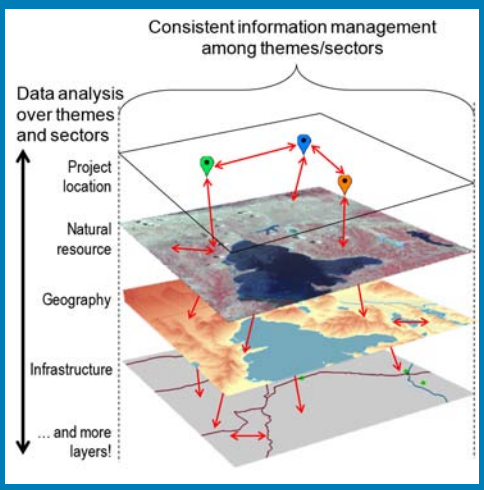
Introduction to Geographic Information Systems

A geographic information systems (GIS) is a system for the management and analysis of geographic information and data, including natural resource maps, urban planning maps, satellite images, remote sensing data, and thematic maps. The basic functions of GIS and its benefits include

(i) Geographic information management. GIS enables efficient management of geographic information and data by storing them in a consistent coordinate system. Users can find information and data over sectors and themes in more intuitive ways than with a keyword search.

(ii) Geographic data analysis. GIS can integrate information and data over sectors and themes by overlay function (e.g., combining a climate map and a population density map). Another analysis function is the ability to measure geographic features in order to determine road length, distance between major cities, size of impact areas, or the most efficient routing. This can make assessment and planning more effective.

Figure 8 Basic Concepts of Geographic Information Management and Geographic Data Analysis



Source: Prepared by the authors.

(iii) Geographic visualization. GIS helps people visualize data and information in the form of maps, which facilitate understanding among stakeholders. It also can provide interactive maps via the Internet, such as Google Maps. Such Internet-based map systems will promote knowledge sharing and public accountability.

Table 4 shows typical applications in each sector in ADB.

Table 4 Typical Applications of Geographic Information Systems in Asian Development Bank Projects

Purpose	Applications
Information management	Urban information systems, project information systems, map/data/information archives and searches by location, interactive web-based GIS for knowledge sharing
Planning and monitoring	Environmental and social impact assessment for safeguards, multisector data analysis, intuitively readable current overview and outlooks by geographic visualization
Presentation and publication	At-a-glance visualization on maps, web-based GIS for the public, quick and easy creation of maps

GIS = geographic information systems.

II Geographic Information System Applications in Asian Development Bank Projects

Table 5 List of Projects Applying Geographic Information Systems

Theme		Country	Project Title	Application
Climate change adaptation		Bangladesh	Strengthening the Resilience of the Water Sector in Khulna to Climate Change (TA 7197-BAN)	Damage/impact model and presentation of results
		Pacific developing member countries	Regional Partnerships for Climate Change Adaptation and Disaster Preparedness (TA 6496-REG)	Open source GIS-based information system to store, manage, and serve the regional and national databases
		Pacific developing member countries	Strengthening the Capacity of the Pacific Developing Member Countries to Respond to Climate Change (TA 7394-REG)	DEM for visibility analysis for wind turbine installation
Disaster management		Bangladesh, Philippines, Viet Nam	Applying Remote Sensing Technology in River Basin Management (TA 8074-REG) (See page 4)	Improvement of flood forecasting using satellite-based rainfall data
Energy		Uzbekistan	Solar Energy Development (TA 8008-UZB) (See page 6)	Solar energy resource map using GIS
		Regional	Energy for All Initiative	GIS analyses for night brightness compared to population density with sattelite night view
Environment		Great Mekong Subregion	Core Environment Program and Biodiversity Conservation Corridors Initiative in the Greater Mekong Subregion (TA 6289-REG)	See 1–5 below.
	1. Strategic environmental assessment	Viet Nam	Land Demand Allocation Modeling in the Strategic Environmental Assessment of the Quang Nam Land Use Plan 2011–2020	Previewing the geographic outcomes of different development priorities
	2. Project preparation	Lao PDR	Spatial Muti-Criteria Assessment for Rubber Plantations in Lao People's Democratic Republic	Mapping land suitability for sustainable investments
	3. Project implementation	Thailand	Modeling Species Distribution and Threats in Tenasserim, Thailand	Assessing biodiversity corridor values
	4. Monitoring and evaluation	Great Mekong Subregion	Mapping Development Activities	Improving collaboration on monitoring and evaluation
	5. Publication and communication	Great Mekong Subregion	Web-Based Interactive Atlas of the Greater Mekong Subregion	Visualizing geographic information
Transport		Kyrgyz Republic, Tajikistan	A Pilot Study on Central Asia Regional Economic Cooperation Corridor Development	Geographic visualization; use of terrain data for analysis of road condition
Urban development		Nepal	Institutional Strengthening of Municipalities (TA 7355-NEP) (See page 14)	GIS tool for municipalities providing urban services
		Metro Manila, Philippines	Services for the Urban Poor (TA 4616-PHI)	Urban poverty analysis, inventory of government-owned lands

CAREC = Central Asia Regional Economic Cooperation, DEM = digital elevation model, GIS = geographic information systems, Lao PDR = Lao People's Democratic Republic.

Strengthening the Resilience of the Water Sector in Khulna to Climate Change

Project Title	Strengthening the Resilience of the Water Sector in Khulna to Climate Change
Project Number	TA 7197-BAN
Country	Bangladesh
Department	South Asia Department/Urban Development Division
Executing Agency	Local Government Division, Ministry of Local Government Rural Development & Cooperation
Sector/Subsector	Agriculture and natural resources/Water-based natural resources management
Amount Approved	$600,000
Approval/Completion	10 December 2008/30 June 2011
Source	http://www.adb.org/projects/42469-012/main
ST/Application	Damage/impact model and presentation of results
ST/GIS Data	QuickBird (Pan-sharpened, 0.60 m, four-band) satellite images, topographic data of the Khulna city area, rainfall of the Khulna region, water level, river discharge, salinity, and drainage data
ST/GIS Cost	Not available
Users	City Region Development Project and the Khulna Water Supply Project

GIS = geographic information systems, ST = space technology.

Context

With vast low-lying areas, Bangladesh is considered one of the most vulnerable countries in the world to climate change. Strengthening the resilience to climate change is pivotal in all its development and poverty alleviation activities. The city of Khulna, located in the coastal area of Bangladesh and influenced by tides from the Bay of Bengal, is highly vulnerable to climate change. This technical assistance project assessed the impacts of climate change and identified adaptation options before two planned water sector investment projects in Khulna, namely the City Region Development Project and the Khulna Water Supply Project.

Contribution of Space Technology and Geographic Information Systems

The analyses of impacts of climate change scenarios on flooding, urban drainage, and salinity intrusion for Khulna were conceived based on dynamic mathematical modeling followed by the presentation of the results in GIS with the following data: (i) topographic data of the Khulna city area, rainfall of the Khulna region, water level, river discharge, salinity, and drainage data collected for the input of the three mathematical models; (ii) satellite image of high resolution (0.6 m, QuickBird) procured for updating the base map for Khulna and also to check the land use patterns; and (iii) other maps procured and collected mainly from Khulna City Corporation and Khulna Development Agency.

Results

The results from the climate model, the urban drainage model, and the socioeconomic and damage profile of the inhabitants from past experiences of disasters were used to estimate the cost of disasters for similar future events based on 2030 and 2050 climate scenarios. This information is now combined with a business-as-usual economic and social scenario for the future to determine the overall damage cost for Khulna.

Regional Partnerships for Climate Change Adaptation and Disaster Preparedness

Project Title	Regional Partnerships for Climate Change Adaptation and Disaster Preparedness
Project Number	TA 6496-REG
Country	Regional (Cook Islands, Fiji Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu)
Department/Division	Pacific Department/Transport, Energy and Natural Resources Division
Executing Agency	Asian Development Bank
Sector/ Subsector	Agriculture and natural resources/Land-based natural resources management
Amount Approved	$1,000,000
Approval/Completion	27 October 2008/31 December 2011
Source	http://www.adb.org/projects/41187-012/main
ST/GIS Application	Open source GIS-based information system to store, manage, and serve the regional and national databases
ST/GIS Data	Satellite imagery, buildings, transportation infrastructure, underground pipe networks, and power distribution network data
ST/GIS Cost	Not available
Users	Pacific Islands Applied Geoscience Commission

GIS = geographic information systems, ST = space technology.

Context

The Pacific region is prone to natural disasters, experiencing droughts, earthquakes, floods, cyclones, landslides, sea surges, tsunamis, and volcanic eruptions. Each Pacific developing member country faces a different set of risks and potential losses with respect to natural disasters. This technical assistance project supported the development of a national and a consolidated regional GIS encompassing hazard and vulnerability data critical to the future development of a Pacific regional catastrophe insurance scheme, and the analysis of this regional data with respect to the suitability of the Pacific region for catastrophe insurance coverage.

Contribution of Geographic Information Systems

The project team designed and deployed a GIS-based information system to store, manage, and serve the regional and national databases. This system was expected to (i) act as a central repository for the regional and national databases, (ii) serve as a data store for running RiskScape models, (iii) publish a browser-based map viewer to view the GIS data online, (iv) disseminate the GIS data using various open standards for GIS data services, such as web map service (WMS), web feature service (WFS), or keyhole markup language (KML), (v) support periodic data updates from national GIS departments, and (vi) support exporting GIS data for extraction to other systems. GIS data was provided by the Pacific Islands Applied Geoscience Commission, and other data such as roads and land use were supplied by the governments or other sources.

Results

The GIS developed proved important for governments and development partners' decision making by providing information about the frequency and impact of hurricanes and earthquakes.

Strengthening the Capacity of the Pacific Developing Member Countries to Respond to Climate Change

Project Title	Strengthening the Capacity of the Pacific Developing Member Countries to Respond to Climate Change
Project Number	TA 7394-REG
Country	Regional (Cook Islands, Fiji Islands, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, Vanuatu)
Department	Pacific Department/Transport, Energy and Natural Resources Division
Executing Agency	Asian Development Bank
Sector/Subsector	Multisector/Multisector
Amount Approved	$3,140,000
Approval/Completion	23 November 2009/5 December 2013
Source	http://www.adb.org/projects/43071-012/main
GIS Application	Digital elevation model (DEM) for visibility analysis for wind turbine installation
GIS Data	DEM data, topographic features, land cover data
GIS Cost	Not available
Users	Yap State Public Service Corporation

GIS = geographic information systems.

Context

This technical assistance project has three primary technical divisions: (i) power generation using solar energy, (ii) power generation using wind energy, and (iii) improved fuel efficiency through the use of a modern diesel engine of a size that is best suited to the base load seen by Yap State Public Service Corporation. This is an environmentally friendly project that will result in substantial energy saving and greenhouse gas emission reduction and improve the energy infrastructure of Yap State. In addition to the significant total savings in gallons of fuel per year, the prevention of associated pollutants from combustion of fossil fuels entering the local airshed is significant.

Contribution of Geographic Information Systems

For the site selection for the wind turbines, wind flow modeling was undertaken for the Yap main islands and used as the basis for assessing potential wind farm locations. The few ridges with sufficient wind for successful turbine operations were subjected to further analysis of constraints including land use, land ownership, access, and transmission feasibility. Only the Merry Tower ridge, with its proximity to Colonia, the existing electricity grid, and existing road access, was found to be technically feasible and financially viable. A DEM was used to delineate the areas in the viewshed of the site. The seen and unseen areas from the center of the site were analyzed.

Results

With the aid of GIS software, the ideal location of wind turbines was realized. The output of analysis shows that the south bank of Colonia Harbor is visible from the ridge, but only a small part of the northern side. Areas extending toward the airport are all within the viewshed of the ridge. This analysis determined the locations for public consultation on visual impact.

Energy for All Initiative

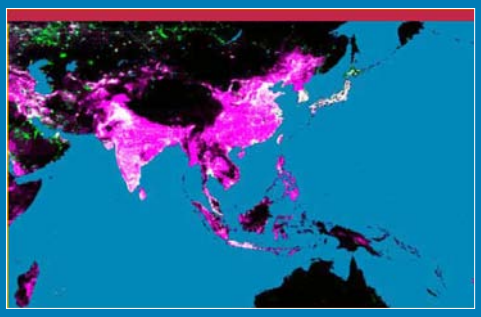
Project Title	Energy for All Initiative
Project Number	N/A
Country	Asia and the Pacific region
Department/Division	Regional and Sustainable Development Department/Sustainable Infrastructure Division
Executing Agency	N/A
Sector/Subsector	Energy
Amount Approved	N/A
Approval/Completion	N/A
Source	http://www.adb.org/sites/default/files/night-skies-electrification-gaps.pdf
ST/GIS Application	GIS analyses for night brightness compared to population density with Satellite nightview
ST/GIS Data	Satellite night view images and population density grid
ST/GIS Cost	Freely available data, analysis by in-house GIS specialist
Users	Public (brochures and flyers)

GIS = geographic information systems, ST = space technology.

Context

ADB aims to maximize energy for all, especially the rural poor, and founded the Energy for All Initiative to strengthen its investments and increase its project portfolio in energy access. The initiative develops and mainstreams approaches for scaling up access to affordable, modern, and clean energy among the region's poor. In order to increase awareness, ADB made a flyer, Energy for All: Asia's Night Skies Reveal Growth and Gaps in Electrification, based on remote sensing data and GIS technology.

Figure 9 Night Brightness Compared to Population Density (2005)



Note: White = High population density, bright night light; Pink = High population density, dark night light; Green = Low population density, bright night light; Black = Low population density, dark night light.
Source: Asian Development Bank. 2011. Energy for All: Asia's Night Skies Reveal Growth and Gaps in Electrification. http://www.adb.org/sites/default/files/night-skies-electrification-gaps.pdf#page=2

Contribution of Geographic Information Systems

This flyer was made with the night views taken by the United States Defense Meteorological Satellite Program satellites, whose Operational Linescan System has a unique capability to detect low levels of visible and near-infrared radiance at night and to remove clouds with its thermal infrared band data. The night view images were overlaid with freely available population density grid data using GIS. Figure 9 illustrates the global energy access situation in Asia and the Pacific by comparing population to brightness. This information shows that much of the region is still dark despite its high population (the pink area).

Results

This image and the flyer have been frequently used in relevant workshops, meetings, and websites. The data helps people understand visually that there is still a lack of energy access in Asia and the Pacific region.

Core Environment Program and Biodiversity Conservation Corridors Initiative in the Greater Mekong Subregion

Project Title	Core Environment Program and Biodiversity Conservation Corridors Initiative in the Greater Mekong Subregion
Project Number	TA 6289-REG
Country	Great Mekong Subregion (Cambodia, PRC, Lao PDR, Myanmar, Thailand, Viet Nam)
Department/Division	Southeast Asia Department/Environment, Natural Resources & Agriculture Division
Executing Agency	Asian Development Bank
Sector/Subsector	Agriculture and natural resources/Land-based natural resources management
Amount Approved	$2,620,000
Approval/Completion	16 December 2005/31 December 2012
Source	http://www.adb.org/projects/39025-012/main
	Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion. http://www.gms-eoc.org/uploads/resources/31/attachment/Applying%20Spatial%20Tools%20to%20Support%20Sustainable%20Planning%20in%20the%20Greater%20Mekong%20Subregion.pdf
GIS Application	Strategic environment assessment Spatial multi-criteria assessment for investments Modeling species distribution and threats for corridor design Mapping development activities Web-based interactive atlas

PRC = People's Republic of China, GIS = geographic information systems, Lao PDR = Lao People's Democratic Republic.

Context

This technical assistance project was aimed to support the long-term strategy toward regional cooperation and integration by strengthening sustainable management of natural resources in the GMS to achieve greater economic growth. The goals of the project were to (i) increase broader awareness of GIS, (ii) demonstrate the usefulness of GIS and its contribution to planning processes, (iii) develop and test dedicated spatial decision support tools, and (iv) build cross-sector conceptual and technical GIS capacity through stand-alone and on-the-job training. The GIS efforts under the project were aligned to the planning cycle shown in Figure 10.

Figure 10 Planning Cycle and Spatial Decision Support Tools

Source: Asian Development Bank. n.d. Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion. http://www.gms-eoc.org/uploads/resources/31/attachment/Applying%20Spatial%20Tools%20to%20Support%20Sustainable%20Planning%20in%20the%20Greater%20Mekong%20Subregion.pdf#page=5

(i) Early in the planning cycle, ex-ante strategic environmental assessments of sector plans and strategies utilizing scenario-based models were conducted to preview the geographic outcomes of different development priorities;
(ii) Identification of locations for sustainable investments were supported by building capacity in spatial multi-criteria assessment;

(iii) On-the-ground interventions such as the establishment of Biodiversity Conservation Corridors were carried out with the help of species and threat modeling tools;
(iv) Ex-post monitoring and evaluation was strengthened by developing crowd-sourced interactive collaboration and mapping tools; and
(v) Awareness raising and targeted dissemination of geographic knowledge to decision makers were supported through the development of an interactive atlas of the GMS.

While spearheading and promoting the integration of advanced GIS applications into each aspect of the planning cycle, the project has recognized the need for developing practical solutions that adjust to the specific context of each GMS country. Therefore, priority has been given to developing robust approaches that can be maintained and institutionalized in government institutions in the long term. Depending on the skills profile and budgetary situation of each individual institution, the project utilized and built capacity on open-source GIS software and stand-alone models (freeware) alongside commercial solutions. The same principle has been applied for interactive collaboration and web-mapping tools, where tools built on freeware (e.g., Development Maptool, or DevMap) have been developed alongside commercial solutions such as ArcGIS Server (for the GMS interactive atlas).

These activities have been led by the GMS Environment Operations Center (http://www.gms-eoc.org/) located in Bangkok, which is funded by ADB and other cofinancing under the technical assistance project. Implementing this approach over 5 years has resulted in several tangible outcomes. Four strategic environmental assessments have made use of land demand allocation models, biodiversity pressure models, and spatial multi-criteria analysis at a level that is considered innovative not only within the region, but also in comparison to global strategic environmental assessment practice. Several hundred staff members from all GMS countries have been trained on GIS. As a result, the Environment Operations Center was able to hand down mapping and monitoring responsibilities to its national focal points and implementing agencies. The following projects are examples of these activities. (Please find the details in Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion; the link is available in the table at the beginning of this section.)

Application 1: Previewing the geographic outcomes of different development priorities
Land demand allocation modeling in the strategic environmental assessment of the Quang Nam Land Use Plan 2011–2020
Application 2: Mapping land suitability for sustainable investments
Spatial multi-criteria assessment (for Lao PDR rubber plantations)
Application 3: Assessing biodiversity corridor values
Modeling species distribution and threats in Tenasserim, Thailand
Application 4: Improving collaboration on monitoring and evaluation
Mapping development activities
Application 5: Visualizing geographic information
Web-based interactive atlas of the Greater Mekong Subregion

Land Demand Allocation Modeling in the Strategic Environmental Assessment of the Quang Nam Land Use Plan 2011–2020

Project Title	Land Demand Allocation Modeling in the Southeast Asia of the Quang Nam Land Use Plan 2011–2020
GIS Application	Previewing the geographic outcomes of different development priorities
GIS Data	Land use
GIS Cost	Not available
Users	Quang Nam Department of Environment and Natural Resources

GIS = geographic information systems.

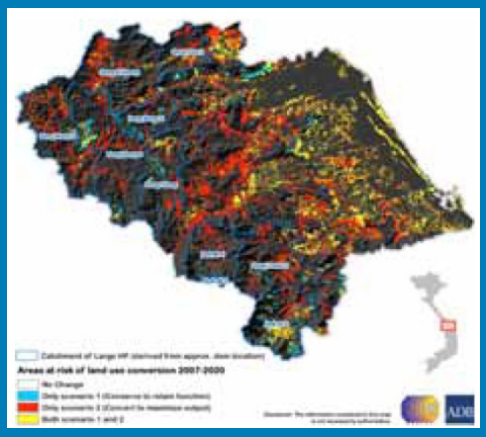
Context

Considering that the present and future economic performance of the Quang Nam Province, located in central Viet Nam, is heavily dependent on sectors that build on a healthy natural resource base (agriculture, forestry, tourism and hydropower), environmentally sound planning approaches need to be piloted and institutionalized. To ensure that its allocation of land and natural resources is aligned well with the carrying capacity of the underlying environment, the Environment Operations Center supported the Quang Nam Department of Environment and Natural Resources (DONRE) in conducting a strategic environmental assessment of its Land Use Plan for 2011–2020.

Contribution of Geographic Information Systems

To highlight the geographic implications of different development priorities with the DONRE land use planning team, the Conversion of Land-Use Change and its Effects land demand allocation model was tested in a pilot application. It provided an important preview of where different priorities and corresponding land demand projections are likely to trigger land conversion in the future, and how these changes are associated with the interests of other development sectors (e.g., tourism, energy such as hydropower), the performance of which depends on intact forest ecosystem services, as shown in Figure 11.

Figure 11 Map of Hydropower Catchments Overlaid on Areas at Risk of Deforestation



Source: Asian Development Bank. n.d. Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion. http://www.gms-eoc.org/uploads/resources/31/attachment/Applying%20Spatial%20Tools%20to%20Support%20Sustainable%20Planning%20in%20the%20Greater%20Mekong%20Subregion.pdf#page=9

Results

Two land conversion maps were produced for the year 2020. One showed the consequences of traditional agricultural expansion, and the second provided a preview of future landscape servicing and maximizing the growth potential of the hydropower and tourism sectors. Land demand allocation modeling was also piloted as part of the strategic environmental assessment of the North–South Economic Corridor Strategy and Action Plan. Both "business-as-usual" and "environmentally optimized" land demand scenarios were translated into maps showing areas at risk of land conversion. This helped the strategic environmental assessment team identify threatened primary forest patches where conservation efforts should be intensified.

Spatial Multi-Criteria Assessment for Rubber Plantations in Lao People's Democratic Republic

Project Title	Spatial Muti-Criteria Assessment for Rubber Plantations in Lao People's Democratic Republic
GIS Application	Mapping land sustainability for sustainable investments
GIS Data	Soil fertility, accessibility, slope, existing land use, existing level of protection
GIS Cost	Not available
Users	Expert group such as Water Resources and Environment Agency, Ministry of Agriculture and Forestry, National Land Management Authority, Ministry of Energy and Mines, and National Tourism Authority

GIS = geographic information systems.

Context

Over the past 2 decades, the GMS has experienced significant economic growth. With investment volume increasing, and much of the natural resources already being allocated, finding suitable areas for additional investments becomes increasingly challenging. Remaining resources may not be of optimal quality and economic opportunity, and additionally, are likely to fall into remote and vulnerable areas that impose higher environmental costs. Additionally, the increasing density of investments also requires factoring in the cumulative impacts of new investments on existing ones. If this complexity is not appropriately considered and addressed in planning and allocating future investments, they might be placed in areas that yield more costs than benefits to both the investor and society.

Contribution of Geographic Information Systems

To address the issues mentioned with suitable planning tools, the Environment Operations Center has taken steps to increase awareness and build conceptual and technical capacity on spatial multi-criteria assessments. This tool is based on collating and structuring knowledge from nonspatial experts in a hierarchical way, which is subsequently translated into a map using a GIS. Executing a geographic criteria tree in a GIS produces a feasibility layer that integrates economic suitability with environmental and social vulnerability and its associated cost implications. Such a layer provides planners with a comprehensive picture of opportunities and implications, reducing the risk of suboptimal allocations for specific investments and maximizing the opportunities between competing sectors.

Results

This functionality was demonstrated in a pilot application on demand for rubber concessions in Lao PDR. A cross-institutional expert group comprised of Water Resources and Environment Agency, Ministry of Agriculture and Forestry, National Land Management Authority, Ministry of Energy and Mines, and the National Tourism Authority was formed and jointly developed a criteria tree for rubber plantations. Nongovernment and international stakeholders were asked to provide additional inputs. The final criteria tree was implemented in a GIS and maps highlighting potential areas for rubber investments were produced. These materials were used as a base for a GIS "training of national trainers," who then applied their knowledge on conceptual design and implementation at the provincial level, conducting an awareness-raising event in Savannakhet Province in June 2010.

Modeling Species Distribution and Threats in Tenasserim, Thailand

Project Title	Modeling Species Distribution and Threats in Tenasserim, Thailand
GIS Application	Assessing biodiversity corridor values
GIS Data	Forest and land-use classification from satellite imagery, GPS field surveys of landscape species
GIS Cost	Not available
Users	Tenasserim BCI Pilot Site under Department of National Parks, Wildlife and Plant Conservation, and Wildlife Conservation Society of Thailand

BCI = Biodiversity Conservation Corridor Initiative, GIS = geographic information systems, GPS = Global Positioning System.

Context

Under this technical assistance project, six conservation corridor pilots have been established, reconnecting important protected areas across the GMS. Local communities were actively involved in restoring ecosystem connectivity, and alternative income opportunities were developed to maintain these achievements and improve local livelihoods at the same time. An important pillar of this success, and a critical prerequisite for further investments, is the establishment of a site-monitoring system that assesses the state of the ecosystem, tracks changes and improvements, and identifies ecosystem service benefits provided to local livelihoods and sector investments (e.g., hydropower, tourism) alike.

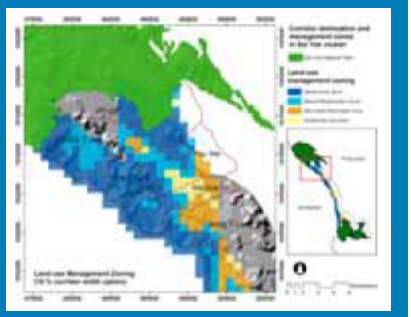
Contribution of Geographic Information Systems

A GIS-based assessment of the site characteristics and values, staggered into three consecutive steps, included: (i) landscape-wide forest and land-use classification (10 classes) from recent satellite imagery, identifying the extent of habitats, habitat fragmentation, and potential corridor strips or stepping stones; (ii) GPS field surveys to point-map the incidence of landscape species and threats in the corridor zone (species mapped included Asian elephant, gaur, serow, great hornbill, common muntjac, Indochinese tiger, leopards, and sambar; human utilization and threats recorded include nontimber forest products collection, hunting, tree cutting, encroachment, and domestic animals); and (iii) extrapolation of the point survey data to get an estimate of the distribution and abundance of landscape species and intensity of human threats within the corridor area.

Results

The results were used to delineate a conservation corridor with a total coverage of 787 km^2, as shown in Figure 12. A further division of the corridor into land use management zones was undertaken based on the percentage of remaining primary forest per grid cell. These management zones are the essential building blocks for corridor planners to direct their interventions to improve connectivity for key landscape species.

Figure 12 Model-Based Corridor Delineation and Management Zones, Sai Yok Cluster of the Tennasserim Biodiversity Conservation Corridor, Thailand



Source: Asian Development Bank. n.d. Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion. http://www.gms-eoc.org/uploads/resources/31/attachment/Applying%20Spatial%20Tools%20to%20Support%20Sustainable%20Planning%20in%20the%20Greater%20Mekong%20Subregion.pdf#page=16

Mapping Development Activities

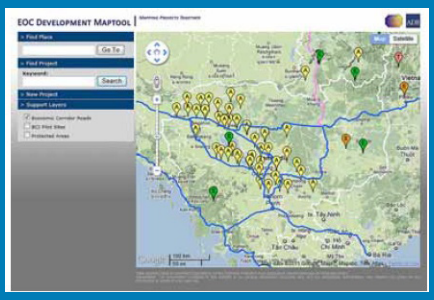
Project Title	Mapping Development Activities
GIS Application	Improving collaboration on monitoring and evaluation
GIS Data	Projects' geographic location
GIS Cost	Not available
Users	Environment Operations Center

GIS = geographic information systems.

Context

In order to design appropriate technical assistance and well-targeted investment projects, planners need to (i) review lessons learned from past projects, (ii) connect with ongoing projects, and (iii) integrate efforts with projects of other development agencies. Being able to efficiently access key information on past, present, and planned project is a critical prerequisite to time-efficient and sound project design. At present, reviewing project portfolios to identify strategic priorities, synergies, and conflicting investments remains time consuming. Existing database designs and formats are often cross-institutionally and even inter-departmentally incompatible, making direct comparison of information difficult.

Figure 13 Development Map Tool Showing the Asian Development Bank Project Portfolio



Source: Asian Development Bank. n.d. Applying Spatial Tools to Support Sustainable Planning in the Greater Mekong Subregion. http://www.gms-eoc.org/uploads/resources/31/attachment/Applying%20Spatial%20Tools%20to%20Support%20Sustainable%20Planning%20in%20the%20Greater%20Mekong%20Subregion.pdf#page=17

Contribution of Geographic Information Systems

One solution to some of these challenges is to combine an interactive web-based map interface with a server-side database. While the web-based map interface serves as a geo-reference to identify project locations, feedback forms allow the user to input additional information on the project and submit project location and description information to the database. From this database an activity layer is generated each time a project is added or updated, and automatically overlaid on the interactive map for easy browsing of the information. Additional support information such as economic corridor roads can be overlaid to increase geographic detail and Context.

Results

The Environment Operations Center has designed such an application and deployed it as the Development Maptool, or DevMap. DevMap makes cross-institutional project planning and coordination easier in several ways. Firstly, it provides an intuitive map interface that facilitates identification of potential synergies and conflicts early on in project planning, as shown in Figure 13. Furthermore, DevMap enables the user to add and update information in real time. DevMap focuses on key information to keep feedback forms short and individual effort low. Lastly, the application is cost-neutral: the client accesses it through a website without any software installation required. It was adapted for the mapping and monitoring of rural health facilities, and for the interactive display of environmental and social indicators. Potential future applications could include the mapping and documentation of soil quality (agriculture sector), construction material sites (transport sector), and forest quality and/or carbon stocks.

Web-Based Interactive Atlas of the Greater Mekong Subregion

Project Title	Web-Based Interactive Atlas of the Greater Mekong Subregion
GIS Application	Visualizing geographic information
GIS Data	Tier 1: Subregional Atlas, Tier 2: Country Atlases, Tier 3: Activity Atlases (satellite images, field survey results), land demand allocation maps, spatial multi-criteria assessment layers
GIS Cost	Not available
Users	National Support Unit and Environment Operations Center for maintenance, Tier 1 for general public and professionals, Tier 2 for Working Group of Environment focal ministries, Tier 3 for Working Group of Environment approved users and Environment Operations Center

GIS = geographic information systems.

Context

More than 1,000 maps have been produced and have supported planners in making more informed decisions as part of ex-ante strategic environmental assessments, Biodiversity Conservation Corridor Project establishment, and ex-post performance monitoring. When it comes to flexibility, however, static maps have limitations. They require dedicated software to handle and view geographic data. Skilled staff are required to collect GIS information first, and then produce maps with the help of this software. And even if they are published in reports and atlases, static maps and the information they contain cannot be adjusted and customized by other users to fit their own requirements. As a result, the use of static maps often remains limited to a single application, despite the fact that their information is often relevant for supporting other projects and the questions they need to answer.

Contribution of Geographic Information Systems

The Environment Operations Center is bridging this gap by integrating its desktop GIS with server capabilities (hardware and software) that can translate geographic datasets into dynamic layers for distribution on the Internet. This GMS interactive atlas consists of three distinct tiers: Tier 1 – Subregional Atlas contains geographic layers that cover the entire area; Tier 2 – Country Atlases holds more detailed national datasets, delivered as country packages, and stacked on top of Tier 1; Tier 3 – Activity Atlases presents national and subregional GIS outputs produced by individual project activities.

Results

The GMS interactive atlas was built on the ArcGIS Application Programming Interface for Microsoft Silverlight, providing a seamless, feature-rich browsing experience. It is accessible through any Internet browser without the need for installing dedicated stand-alone software. The initial functionality of the GMS interactive atlas features browsing and querying. It will be upgraded incrementally with basic geoprocessing tools to allow more experienced users to perform simple analytical tasks.

A Pilot Study on Central Asia Regional Economic Cooperation Corridor Development

Project Title	A Pilot Study on Central Asia Regional Economic Cooperation (CAREC) Corridor Development
Project Number	N/A
Country	Kyrgyz Republic and Tajikistan
Department/Division	Central West Asia Department/Regional Cooperation and Operations Coordination Division
Executing Agency	N/A
Sector/Subsector	Transport
Amount Approved	N/A
Approval/Completion	N/A
Source	http://www.carecprogram.org/uploads/events/2012/SOM-Oct/002_112_209_Pilot-Study-on-CAREC-Corridor-Development.pdf
GIS Application	Geographic visualization of study results; use of terrain data for analysis of road conditions
GIS Data	OpenStreetMap; digital elevation model provided by Shuttle Radar Topography Mission; population data by city with coordinates
GIS Cost	GIS specialist's effort
Users	N/A

GIS = geographic information systems, N/A = not applicable.

Context

The Central Asia Regional Economic Cooperation (CAREC) focuses on two complementary strategic objectives: (i) expanding trade and (ii) improving competitiveness. These objectives are designed to reinforce each other and contribute to the attainment of CAREC's goal of development through cooperation. To achieve these objectives, operational priorities will be pursued, comprising: (i) the four core sectors of cooperation—transport, trade facilitation, trade policy, and energy; (ii) economic corridor development; and (iii) the CAREC Institute. This study analyzes economic corridor development by focusing, as a pilot, on CAREC Corridor 5, Tajikistan and Kyrgyz Republic segments.

Contribution of Geographic Information Systems

Since there was lack of comprehensive statistics on regional transport, the team had to collect data and information from various sources including CAREC Corridor Performance Measurement & Monitoring Report 2011, past studies, UN statistics, national statistics, and meetings with authorities. GIS contributed to organizing the fragmented data and information into maps. In addition, GIS enabled a geographic analysis showing altitude and slope along with the corridor. Another feature of the GIS application in this study is applying OpenStreetMap, a GIS dataset produced by volunteers. OpenStreetMap was the only up-to-date source with enough detailed GIS road data.

Results

The result was presented at the CAREC Senior Officials' Meeting in October 2012. The presentation with geographic visualization effectively showed the current status of transportation on the CAREC Corridor 5 with geographical factors including length, location of logistic center, and terrain condition.

Metro Manila Services for the Urban Poor

Project Title	Metro Manila Services for the Urban Poor
Project Number	TA 4616-PHI
Country	Philippines
Department/Division	Southeast Asia Department/Human and Social Development Division
Executing Agency	Housing and Urban Development Coordinating Council
Sector/Subsector	Water supply and other municipal infrastructure and services/Urban sector development
Amount Approved	$700,000
Approval/Completion	19 July 2005/30 June 2010
Source	http://www.adb.org/projects/38398-012/main
GIS Application	Urban poverty analysis, inventory of government-owned lands
GIS Data	Aerial photography
GIS Cost	Not available
Users	Philippine Land and Asset Management System

GIS = geographic information systems.

Context

This technical assistance project aims to assist the government in its asset reform agenda, and in implementation of a phased, metropolitan-wide, 15-year strategy for slum eradication and urban upgrading in Metro Manila. It will initiate a process for formulating local government unit–level integrated urban development interventions in support of the strategy, including support for the transfer of national government lands to local governments, and will prepare an investment project for high priority sites within Metro Manila.

Contribution of Geographic Information Systems

A comprehensive map-based data build-up on the current state of physical resource uses of the entire Metro Manila coverage area was conducted. Rapid land assessment techniques, through the use of advanced technology-led approaches, such as the combination of remote sensing and GIS, were employed to acquire new and periodically updated physical data on the national capital region and its peripheries. Research on the inventory of government-owned lands was completed and mapped on the GIS platform. GIS-based urban poverty analysis techniques were facilitated to monitor growth, expansion, and movement of informal settlement communities.

Results

Map data for 2005 from the Urban Asset Reform Project Management Office under the Office of the President show the magnitude of depressed settlements in Metro Manila. The Urban Asset Reform Project Management Office also reported that informal settlers occupy almost 3% or 1,835.12 hectares of the total land area of Metro Manila. This means that there is an informal settlement community in every 3 hectares of land in the national capital region. These statistics demonstrated how poorly utilized government lands are, and underscore the urgency of introducing reforms in the Philippine Land and Asset Management System that will advocate the adoption of innovative and definitive practices, especially in Metro Manila.

Space Technology and Geographic Information Systems Applications in ADB Projects

Space technology and geographic information systems (GIS) have now become valuable tools in helping development organizations achieve their missions. They can be applied to various development sectors including agriculture, rural development, and food security; education; energy; environment; climate change; health; pubic management and governance (especially disaster risk management); transport; urban development; and water management.

This report provides an overview of the space technology and GIS applications in ADB to date by introducing some of the past and ongoing ADB projects that have applied space technology and/or GIS. It includes information about how the technologies were applied, the service providers, and the cost for the application, so that practitioners including staff of development organizations and government staff in DMCs can easily apply similar technologies to their projects and/or daily operations.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to approximately two-thirds of the world's poor: 1.6 billion people who live on less than $2 a day, with 733 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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