TC DOCUMENT
RG-T2659
Development of High-Resolution Remote Sensing Data Sets and Applications for Water Security and Climate Adaptation in Latin America

I. Basic TC Information

▪ Country/Region:	REGIONAL
▪ TC Name:	Development of High-Resolution Remote Sensing Data Sets and Applications for Water Security and Climate Adaptation in Latin America
▪ TC number:	RG-T2659
▪ Team Leader/Team members:	Fernando Soares Bretas (INE/WSA), Team Leader; Pedro Coli, Juliana Corrales and Liliana López (INE/WSA); Omar Garzonio (WSA/CBO); Javier Jiménez Mosquera (LEG/SGO); Alfred Grunwaldt (INE/CCS); and Raul Muñoz (ESG)
▪ Indicate if:	Knowledge Generation and Dissemination
▪ Date of the TC abstract authorization:	November 3, 2015
▪ Reference to request:	N/A
▪ Beneficiary (countries or entities, which are recipient of the technical assistance):	Latin America Region
▪ Executing agency and contact name:	Inter-American Development Bank (IADB)
▪ Donors providing funding	Latin American Investment Facility (LAIF)[1]*
▪ IDB funding requested:	US$1,000,000
▪ Local counterpart funding, if any:	None
▪ Disbursement period: ▪ Execution period:	32 months 24 months
▪ Required start date:	January, 2016
▪ Types of consultants (firms or individual consultants):	Firm and individual consultants
▪ Prepared by Unit:	INE/WSA
▪ Unit of Disbursement Responsibility:	INE/WSA
▪ TC included in Country Strategy: ▪ TC included in CPD:	N/A N/A
▪ GCI-9 Sector Priority:	Climate Change and Environmental Sustainability

II. Objective and Justification of the TC

2.1 Water security is a contributing factor in all aspects of economic and social development. Improving the security and resilience of drinking water and wastewater infrastructures is vital to ensure the provision of clean and safe water. Provide water security is especially

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important in the Latin America region where water supply, sanitation, and a healthy environment form the basis to successfully reduce poverty and develop shared-growth strategies. Effective water management policies, investments in agriculture and other water-reliant sectors that generate income for poor communities, and the provision of reliable and adequate water resources and services are a key factor in achieving water security for poor people.

2.2 In order to provide water security, decision-makers need to have accurate information of biophysical parameters relevant to the hydrology and meteorology of the region, which are spatially distributed and may present significant temporal variability. However, in developing countries and most certainly in the case of the Latin America region, groundwater information, water quality data, and even basic hydro-meteorological data may be scarce and in some cases do not have quality assurance and control processes in place to guarantee the quality of the data.

2.3 When there is insufficient temporal and spatial data collected within an area of concern, Remote Sensing (RS) provides an approach for estimating and mapping environmental parameters, such as soil, land, and crop characteristics. RS is refers to the technology of collecting information about the Earth surface (land and ocean) and atmospheric from a distance, using sensors onboard satellites or aircraft. This practice involves the collection and analysis of reflected light from the Earth. There are two main types of remote sensing tools: passive and active. Passive tools include satellite sensors, camera fil or digital cameras that respond to external stimuli to record natural energy that is reflected or emitted from the Earth's surface. The most common source of radiation detected by passive tools is reflected sunlight. In contrast, active tools use internal stimuli to collect data about Earth. For instance, a laser-beam remote sensing system projects a laser onto the surface of Earth and measures the time that it takes for the laser to reflect back to its sensor.

2.4 Application areas for RS include the *energy* (biomass energy and forest inventory), *water* (prevention and management of draughts, floods, monitoring of water quality, observations of the temporal and spatial variations in water volumes stored in rivers, lakes, and wetlands in order to fulfill water demands), and the *environmen*t (detection of pollution, measurement of the climate change, monitoring of urban growth and management of urban planning, data assimilation with large-scale models). RS products can also be used in other applications involving the water-energy-food nexus, governance and adaptive management, or transboundary settings. RS data might help to adjust past policies or provide information from parts of a basin lying outside a nation’s borders to facilitate early warnings.

2.5 The use of RS for hydrology and water resources operational purposes, while not new, definitely is a fast-growing field that can provide useful, efficient, and effective information to create innovative solutions for water security and fill the gap on data availability to strengthen water resources management. RS offers a solution to the data-scarcity problem in the Latin American region by providing relevant data on surface water resources, land cover, surface geology, water quality, temperature, and soil moisture among other (bio) geophysical parameters.

2.6 For instance, in poorly gaged basins with times of concentration of several days, real-time satellite estimates of precipitation and derived streamflow forecasts can help managers allocate water among users and operate reservoirs more efficiently. In large

rivers, satellite data on the river and lake surface elevation can be used to estimate flow in the upper parts of the basin and make predictions for downstream flows. Soil moisture observations may give insights into how much irrigation is needed, and help forecast and monitor drought conditions as well. Furthermore, RS allows monitoring of surface water quality parameters to assess the repercussions of river basin management policies, land use practices, and non-point source pollution, as well as to monitor the likelihood of algal blooms and other water quality threats to water supply systems.

2.7 The output of a remote sensing system is usually an image representing the scene being observed. Image analysis and interpretation is a further step to extract useful information. Therefore, in order to fully exploit all the potential offered by the RS tools and to actually explore all areas of applications with a very high societal impact, high-resolution processing methods for assimilation and use of RS data are required. In addition, the combination of RS observations with climate impact studies using land surface and hydrological models (such as Hydro-BID) offers an advantage stage to inform adaptation to climate and global change. As part of IDB commitment to help member countries adapt to climate change, the Bank has sponsored a regional technical cooperation project (RG-T2343) under which the Hydro-BID model has been used to estimate the availability (volumes and fluxes) of freshwater at the regional and basin scales.

2.8 In some areas, the integration of RS tools with in-situ measurements could improve the capability to analyze, monitor, and forecast a wide range of water related operations, which ultimately will help engineers and decision-makers to make scientific-sound decisions for water resources management. In other areas however, in-situ observations remain key for water related operations, because either RS cannot extract all the required information or is simply too expensive to implement. Only a few practitioners understand all of the available RS tools, their costs, limitations, and capabilities. Bank staff and its client counterparts are in need of guidance and direction in order to incorporate RS tools for better decision-making. The term “operational,” as used here, pertains not to the readiness of RS products themselves, but to the actual *use* of these products by decision makers to make or modify a decision.

2.9 Therefore, the objectives of this TC project are four-fold:

1) This TC will assess various satellite imagery providers and RS products available for water-related operations and to identify prospective areas of application for solving water resources management problems. In addition, this TC will give insight on the potential and limitations, data accessibility, and costs of RS tools, describe how remotely sensed data can jointly be used with in-situ measurements to improve results, and to explain the validation and evaluation processes to better inform the client and enhance Bank water-related operations.
2) A high-resolution dataset of key environmental parameters will be developed and integrated into Hydro-BID modules in order to obtain not only new datasets but also higher spatial resolution water balances from the rapidly changing surface of the Earth, which ultimately can support more accurate decisions on water resources management.
3) The synergetic potential of high-resolution RS data and Hydro-BID will be explored through case studies applications in the Latin American region.

4) All the knowledge generated through this TC project will be disseminated by creating several seminar/workshops, technical notes and peer-review journal publications.

III. Description of Activities

3.1 The project will support the development of methodologies and outputs consisting of the following activities:

3.2 **Component 1 – Evaluation of Remote Sensing (RS) Tools for Water Security and Climate Adaptation (US$50,000).** This component includes a literature review to: i) identify satellite imagery providers, RS's advantages, limitations, areas of application, and validation procedures; ii) assess the capabilities of RS tools to fill biophysical data gaps in the Latin America region; iii) provide different image processing techniques to correct for atmospheric factors and to enhance visual interpretation; iv) evaluate how satellite-related technologies can be integrated with in-situ monitoring programs to improve results; and v) present through case studies how engineers, scientists, and decision-makers have used RS tools to address water resources management challenges. Some experiences on the use of RS tools in the Latin America region are discussed in different journal articles. For instance, Giraut et al., (2000) and Parmuchi et al., (2000) used Landsat TM and Radarsat sensors to evaluate flooding in the Parana River and Delta in Argentina. Likewise, Veneziani et al., (1998) and Metternicht and Fermont (1998) used aerial photographs Landsat TM to evaluate drainage density, water infiltration, surface erosion features in the Taquari River basin in Brazil and Sacaba Valey in Bolivia, respectively. This component will present a large set of publications that report on RS research undertaken in region for near-real time monitoring of flood, drought events, irrigation management, and water contamination.

3.3 This detailed discussion will help to better inform the client for deciding whether the use of RS products could be worthwhile in a specific situation and enhance water-related operations. In addition, this evaluation will help to identify different types of water resources management problems where RS tools can be applied. This analysis will provide guidance to Bank staff by showing when, how and which RS instruments are desirable to apply based upon their project needs and constraints. This will place the foundation for the actual application of RS instruments in case studies in the Latin America region. The criteria for the selection of the case studies are presented in Component 3.

3.4 The results of this literature review will be presented in a technical note.

3.5 The work under this component will be performed by a consulting firm or university that has proven experience and technical capacity related to RS tools for water security and climate adaptation.

3.6 **Component 2 – Development of High-resolution RS Products for Water Resources Management (US$350,000).** This component will consist of applying processing techniques to extract information from RS images and create GIS map layers of high-resolution (order of meters spatially and sub-hour temporally) of key environmental parameters that can be used for water resources management. Environmental parameters will include precipitation, evapotranspiration (ET), temperature, soil moisture, land use, crop yield, crop type, groundwater, and water quantity (surface flows) and

quality (sediment and phytoplankton concentrations) variables among other environmental parameters.

3.7 The final product of this component will be a high-resolution spatial dataset of key bio-physical and meteorological variables for the Latin America region. It is worth noting that such high resolution data do not yet exist for the Latin America region, and this dataset product will be a primary contribution of this TC. Each of the environmental parameters, obtained from satellite images, will be represented in GIS maps to facilitate further examination and they will be incorporated into the Hydro-BID model for analysis of water scarcity (droughts), inundation (floods) and water quality (pollution) management problems under Component 3.

3.8 The work under this component will be performed by a consulting firm or university that has proven experience and technical capacity related to RS tools for water security and climate adaptation.

3.9 **Component 3 – Case Study Applications (US$450,000)**. This component will apply RS products from Component 2 in countries/watersheds that are presenting problems related to: i) data scarcity; ii) climate variability; and iii) agricultural and water systems planning and management. Water resources management data will be derived through the Bank's existing Hydro-BID system for water availability (water sources and quantities), water demand use and efficiency data available from INE/WSA clients through the region (e.g., Autoridad Nacional del Agua (ANA) in Perú, and Agencia Pernambucana de Aguas y Clima (APAC) in Brazil). We anticipate that three (3) case studies will be carried out under this component. Each case study will be chosen to reflect a different problem (droughts, floods, and water pollution) and will involve clients in the Latin America region that have expressed interest and need of high-resolution RS data.

3.10 The results of the applied integration of high-resolution RS data and hydro-BID model will be presented in a technical note and disseminated in different workshops conducted under Component 4.

3.11 The work under this component will be performed most likely by the consulting firm or university that developed the RS tools with the supervision of the Bank. The consulting firm or university will have the technical capacity of running and implementing the developed tools for the pilot case study applications.

3.12 **Component 4 - Knowledge Dissemination (US$150,000).** This component will include seminar/workshop(s) to disseminate knowledge regarding the potential and capabilities of RS tools for supporting water and environmental management decisions. It will also include a series of 4-6 workshops for capacity building related to the synergistic potential of high-resolution RS data and Hydro-BID modules: 1-2 within the IADB, and other 3-4 in the region, either organized and called for IADB itself, or through organization of special sessions in conferences in the region and worldwide.

3.13 The work under this component will be performed by the consulting firm or university that developed the RS tools and carried out the case study applications. The objective is that the consulting firm or university disseminates the technical knowledge of the products developed under this TC to the Bank staff and to our clients in the region.

IV. Budget

4.1 An indicative budget is presented below. These TC components will be financed with the EU´s Latin American Investment Facility (LAIF), through the Spanish Agency for International Cooperation (AECID).

Indicative Budget (in US$)*

Component	Total Funding (LAIF)
1. Evaluation of the potential of remote sensing (RS) tools for water security and climate adaptation	50,000
2. Development of high-resolution RS products for water resources management	350,000
3. Case study applications	450,000
4. Knowledge dissemination and working/journal papers	150,000
TOTAL	**US$1,000,000**

***** for detailed TC budget, see link

V. Indicative Results Matrix

Outcome Indicators	Units of Measure	Baseline	Year 1	Year 2	Means of verification
Institutions/entities within the Latin America region make use of Remote Sensing products for operational decision-making in water resources management applications	Institutions/entities	0	1	2	Progress and Final Reports
High-resolution Remote Sensing datasets of key environmental parameters are developed	GIS maps	0	1	2	Progress and Final Reports
Remote Sensing data are used for water security planning, management and decision-making actions, and incorporated into Hydro-BID for analysis of droughts, floods, and water quality pollution	Number of times	0	1	2	Progress and Final Reports
The analysis completed has been used as input in the preparation of loan operations	Number of times	0	0	1	Identification of loan operations
Output Indicators	**Units of Measure**	**Baseline**	**Year 1**	**Year 2**	**Means of verification**
Component 1: Evaluation of the potential of RS tools for water security and climate adaptation					
Remote Sensing technologies and their applications towards water security issues in the Latin America region are assessed	Remote Sensing tools assessed	0	1	1	Progress and Final Reports
Number of countries/ watersheds for Remote Sensing applications are identified	Countries/ watersheds	0	3	0	Progress and Final Reports
Technical note is submitted	Technical notes	0	1	0	Technical notes submitted by consultants
Component 2: Development of high-resolution RS products for water resources management					
Satellite Remote Sensing images are processed. Key environmental	GIS maps	0	3	9	Progress and Final Reports

Outcome Indicators	Units of Measure	Baseline	Year 1	Year 2	Means of verification
parameters information is extracted, mapped, and analyzed					
New high-resolution datasets of biophysical parameters are created	Datasets	0	0	1	Progress and Final Reports
Training and capacity building workshops on image processing techniques and data visualization are conducted	Workshops	0	2	0	List of participants and knowledge products submitted by consultants
Component 3: Case study applications					
Remote Sensing datasets are incorporated into Hydro-BID for water security case study applications	Case studies	0	0	3	Progress and Final Reports
Technical notes on case studies are submitted	Technical notes	0	0	3	Technical notes submitted by consultants
Component 4: Knowledge dissemination					
Dissemination and engagement workshops on case studies of Remote Sensing applications are delivered	Workshops	0	0	1-2	List of participants and knowledge products submitted by consultants
Training and capacity building workshops on the integration of Remote Sensing tools with in-situ measurements and Hydro-BID for personnel in the countries/ watersheds selected are conducted	Training sessions	0	0	3-4	List of participants and knowledge products submitted by consultants

VI. Executing Agency and Execution Structure

6.1 This is a Bank-originated TC focused on integrating recently developed methods and tools in modeling, visualization and decision-making processes, which that are particularly applicable to water scarce areas as case study applications that may be replicated in other climate-sensitive parts of the Latin America region. In addition, this detailed research and development effort will add value by offering the opportunity of mainstreaming climate change impacts in the design of water resources planning and Bank´ infrastructure operations in different sectors (Water Supply, Water Resources Management, Hydro-energy, Irrigation, Natural Hazards and Risk Management and Transport). Besides the water resources management and planning uses of Hydro-BID and new developed high-resolution models, the knowledge and tools developed through this TC will be able to serve as support for the environmental evaluation and screening of Bank´s project loans at regional scale. The execution of this TC will provide a learning, knowledge transfer and data gathering opportunity for Bank staff involved in issues of water resources, vulnerability and adaptation to climate change, which is an increasing area of work for the Bank (and particularly the WSA division). Therefore, it is deemed critical that this TC is Bank-executed.

6.2 Procurement. The Bank will contract individual consultants, consulting firms and non-consulting services in accordance with Bank's current procurement policies and procedures.

VII. Project Risks and Issues

7.1 The primary risk for implementation of this TC project is the lack of technical capacity of some of Bank´s clients and the gap of information for model parameterization in particular areas. To mitigate this risk, the TC includes providing technical support and guidance to model users and building capacity with our client country counterparts (e.g., *Autoridad Nacional del Agua* (ANA) in Peru, and *Agencia Pernambucana de Aguas y Clima* (APAC) in Brazil), as well as with a local universities to sustain this effort beyond the duration of this TC. An additional risk stems from the pioneering nature of this TC; there isn't much operational experience with the kinds of products that this TC will yield. We have therefore included peer review of all outputs of this TC by at least two anonymous reviewers (one within the Bank and one outside the Bank) to insure quality of the TC deliverables.

VIII. Exceptions to Bank Policy

8.1 This TC does not involve any exceptions to the Bank's Policies.

IX. Environmental and Social Strategy

9.1 Following ESG's project classification process (Safeguard Policy Filter and Safeguard Screening Form), it has been determined that this project falls under Category "C". No environmental assessment studies or consultations are required for Category "C" operations.

Annexes:

- ✓ Terms of Reference
- ✓ Procurement Plan

DEVELOPMENT OF HIGH-RESOLUTION REMOTE SENSING DATA SETS AND APPLICATIONS FOR WATER SECURITY AND CLIMATE ADAPTATION IN LATIN AMERICA

RG-T2659

CERTIFICATION

I hereby certify that this operation was approved for financing under AECID/LAF Trust Fund through a communication dated October 6, 2015 and signed by Carmen Jover Gomez-Ferrer, Chief of the Department of the Fund for Cooperation for Water and Sanitation within the Spanish Agency for International Cooperation and Development (AECID). Also, I certify that resources from said fund are available for up to **US$1.000.000** in order to finance the activities described and budgeted in this document. This certification reserves resources for the referenced project for a period of four (4) calendar months counted from the date of eligibility from the funding source. If the project is not approved by the IDB within that period, the reserve of resources will be cancelled, except in the case a new certification is granted. The commitment and disbursement of these resources shall be made only by the Bank in US dollars. The same currency shall be used to stipulate the remuneration and payments to consultants, except in the case of local consultants working in their own borrowing member country who shall have their remuneration defined and paid in the currency of such country. No resources of the Fund shall be made available to cover amounts greater than the amount certified herein above for the implementation of this operation. Amounts greater than the certified amount may arise from commitments on contracts denominated in a currency other than the Fund currency, resulting in currency exchange rate differences, for which the Fund is not at risk.

(Original signed) — 01/08/2016

Sonia M. Rivera
Chief
Grants and Co-Financing Management Unit
ORP/GCM

Date

Approved: *(Original signed)* — 01/14/2016

Pablo Pereira Dos Santos
Sector Manager
Infrastructure and Environment Sector
INE

Date