

8. Strategic Research Portfolio: Information Systems for Water, Land and Ecosystems

Our vision: better information enables better management of water, land and ecosystems.

Our vision is of a world where decisions on natural resource and environmental policy and management in agriculture are increasingly based upon sound scientific evidence. Farmers, resource managers, planners and politicians will rely on ready access to site-specific data on land, water and ecosystems to increase productivity and enhance the ability of people to sustain ecosystem services. Participatory approaches using this information will be greatly enhanced.

Global and regional agro-ecological information and assessment tools will be made available through user-friendly interfaces to stakeholders, including other SRPs in CRP5 and other CRPs. We will develop innovative spatio-temporal surveillance methods and standards to facilitate evidence-based planning and evaluation of agricultural interventions, and we will improve the ability of stakeholders to develop information and surveillance systems in data-sparse regions. (see Box 8.1 for an explanation of surveillance).

Box 8.1. Surveillance

Surveillance is the ongoing, systematic collection, analysis and interpretation of data essential to the planning, implementation and evaluation of land and water management policy and practice, and the application of these data to promote, protect and restore land, water and ecosystem health. A surveillance system includes a functional capacity for data collection, analysis and dissemination linked to land and water management programs. Spatio-temporal surveillance places emphasis on location-specific monitoring using scientifically rigorous protocols.

8.1. The compelling need for this research

Current land and water planning and management approaches in the developing world use at best rather general or insubstantial information on land use and the state of the environment (Paradzayi and R  ther, 2002). Data collected are rarely comparable across ecological zones because of inconsistencies in methods or in the spatial scale at which observations are made. Most long-term ecological monitoring networks have focused on natural ecosystems rather than agro-ecosystems (Sachs et al., 2010), and such data are rarely available in developing countries (Vorosmarty et al., 2002). The absence of systematic data collection and processing not only limits evidence-based planning but also prevents reliable feedback and learning mechanisms on what works, where it works, and why it works (see Box 8.2).

Deploying scientific, evidence-based and location-specific surveillance approaches, similar to those used in public health surveillance, has potential to accelerate reliable learning on agro-ecosystem management through systematic monitoring of resource conditions, trends, risks and intervention impacts. Modern earth observation techniques have potential to put such approaches into operation and provide specific empirical information on the state of land and water resources, and on the impact of interventions at different scales. Remote sensing techniques are available or emerging that enable measurement, monitoring, modeling and

mapping of vegetation condition, soil fertility, soil moisture status, groundwater levels, water quality, and other elements of the hydrological cycle (e.g. Bjerklie et al., 2003; Tang et al., 2009; Wagner et al., 2009). New multifractal scaling theory, for example, could offer an efficient means of providing information at different spatial scales for decision-making at reasonable costs (e.g. Posadas et al., 2005). The challenge is to apply these scientific and technological advances to routine operations in water, land and agricultural management.

Box 8.2. Lessons learned

There is a large gap between the potential and actual use of environmental information in decision-making (e.g. Paradzayi and R  ther, 2002). For example, despite the role of remote sensing in problem identification and policy formulation, policy implementation, and policy control and evaluation, de Leeuw et al. (2010) found that out of more than 300 peer-reviewed articles, none described actual policy support. A key challenge for this SRP is to make better use of the latest geo-information and surveillance science and technology. Some examples of successful applications of information and surveillance systems in land and water management are summarized below.

The Africa Soil Information Service (AfSIS; www.africasoils.net) has attracted US\$18 million in funding over four years to provide new empirical data on the functional capacity of African soils and make this information widely available to farming communities, extension services, development workers, project designers, planners, policymakers, the private sector and scientists. The project is building a soil health surveillance system based on recent CGIAR advances in digital soil mapping, infrared spectroscopy, remote sensing, statistics and integrated soil fertility management to improve the way that soils are evaluated, mapped and monitored. An important component of the project is the use of standardized protocols for measurement, data management and statistical analysis. These are being taken up by a number of sustainable land management and conservation projects outside the CGIAR system for intervention targeting and impact monitoring. These include the private sector in Kenya for rangeland management, Mars Inc. for improving smallholder cocoa production in West Africa, the Kenyan Government for carbon inventories of Mount Kenya, and sustainable land management projects in China, Kenya, Rwanda and Uganda. Dissemination occurs through web-based interfaces and on-the-job capacity building. New thinking is needed to migrate the project to a demand-driven service provider operating with a business mindset, but backed up by solid science.

Water Information Systems are an essential component in the successful management of water resources and in targeting appropriate interventions. IWMI has developed various tools, frameworks and datasets for this purpose, including global data sets and maps on Environmental Flow Requirements and Environmental Water Stress, a Water Atlas (www.iwmi.cgiar.org/WAtlas/Default.aspx), a Water Accounting Framework, approaches for hydronomic zoning, mapping water availability, crop water productivity, wetlands, and global maps of irrigated and rainfed areas (www.iwmi.org/info/main/index.asp).

Some prototype tools, such as drought monitoring systems, are based on remote sensing; others, such as water audit systems (<http://slwa.iwmi.org/>), include spatial, time series, social and legal information that can be updated to monitor the overall status of water resources at a national scale.

We do not know whether we have provided information effectively until we observe changes. There are unprecedented opportunities for leveraging information and communications technology to help the poor through improved policies and planning and even direct provision of information services to land users.

Widespread access to computing and low-cost connectivity is transforming the way science for development is conducted (Ballantyne et al., 2010). Advances in web services, applications programming interfaces, cloud computing and automated work flows are enabling researchers to explore massive datasets and cooperate in new ways. Meanwhile, rapid developments in digital platforms and interfaces and open standards that facilitate interoperability across systems are providing new opportunities for universal access to science data products, tools and information. Mobile phone technology is opening up possibilities for two-way data and information flow with resource-poor land and water users in remote areas.

A key challenge for this SRP is to harness these advances for both accelerated scientific progress and effective decision support for stakeholders at different levels, and to engage stakeholders in surveillance and information and systems design and evaluation, so that evidenced-based decision-making becomes part of everyday policy and practice.

8.2. A compelling role for the CGIAR

The need for this SRP is succinctly expressed by the winner of the 2009 Nobel Prize in Economics Elinor Ostrom (2006), who argues that the study of complex ecosystems requires the conduct of, “long-term research programs that use research methods that focus at different temporal and spatial scales, such as time series remote sensing images, repeated on-the-ground social-ecological surveys of local stakeholders and their [resources], and experimental laboratory studies.” The big gap that the CGIAR can fill is to co-develop, apply and disseminate new methods, protocols and tools for improving and standardizing the way spatio-temporal data on water, land and ecosystems is generated, stored, aggregated, transformed and communicated, to better inform decision-making at local to global levels. The CGIAR has notable experience in the development and practice of information systems (Box 8.3). This new opportunity for the CGIAR is further expanded in the following section.

Box 8.3. Examples of other CGIAR spatial information and surveillance systems

- Africa Environmental Information System, including mapping of land–water health metrics encompassing evapotranspiration, water productivity, irrigated area and estimates of biomass (ICRAF-IWMI)
- DIVA GIS – free open source GIS system (CIP)
- Spatial pest and disease modeling (CIP)
- Climate reconstruction, data gap filling, interpolation and downscaling tools (CIP)
- Landslide modeling (CIP-WUR)
- 3-D internet-based modeling interface for soil and water modeling (CIP)
- Crop wild relatives information at global level (Bioversity International)
- Digital Soil Map of the World initiative (www.globalsoilmap.net) linked to AfSIS.

8.3. The scope and depth of the opportunity

Remote sensing has potential to provide low-cost, location-specific information to aid land and water management decisions, but the ability to deliver reliable information is impeded by lack of consistent ground data for its calibration and interpretation. However, on-the-ground monitoring is seldom rewarded by funding agencies (Nisbet, 2007), despite being one of the

most deserving areas for future investment (Patching together a world view, 2007). The CGIAR has a comparative advantage in designing scientifically rigorous ground-sampling protocols across sentinel sites⁸, and providing oversight and capacity building in systematic data collection, management and analysis.

Data collection and management of natural resources needs long-term thinking. Tighter connections are needed with providers of remote sensing data such as the National Aeronautics and Space Administration (NASA), the United States Geological Survey (USGS), the European Space Agency (ESA) and the Joint Research Centre of the European Commission (JRC) as well as with global environmental data archives, such as the Global Monitoring for Environment and Security (GMES). CGIAR long-term monitoring sites can provide essential calibration and validation data for remote sensing algorithms and applications.

Land and water management interventions are seldom monitored systematically in a scientifically rigorous and integrated way, especially at the programmatic level. As a result, there is little reliable knowledge on what works, where and why. The CGIAR can change this by developing and implementing scientifically rigorous monitoring protocols for intervention evaluation across sentinel sites. There is further potential to integrate land and water surveillance systems with those on human welfare, including human health, towards fully integrated surveillance systems.

Stakeholders at all levels can benefit from improved information systems, but their relevance and use is often limited by a number of factors, including the degree of participation in their development, the demand for the information, ease of access and technical capacity. The CGIAR consortium is well placed to provide a boundary-spanning role (Clark et al., 2011; Giller et al., 2008), sharing science and technology with stakeholders at the different levels and harnessing digital technology to provide easy-to-use and relevant applications. This includes engaging local communities in data collection and providing them with location-specific information.

Data sharing by national programmes, especially on water (streamflow, rainfall and groundwater), is a constraint to development of surveillance systems. Innovation is needed to encourage data sharing. Development of open data-sharing platforms that encourage others to share data could encourage or put pressure on governments and other agencies to release valuable data and information into the public domain. Highly effective spatial decision support tools could provide incentive for programmes to contribute data. Alternatively, open access to remote sensing data could lessen the need for governments to restrict access to information.

8.4. Our Theory of Change for information systems

⁸ The aim of this approach is to obtain high-quality, consistent data from a network of sites selected to sample a wide range of conditions or specific target conditions. The type and size of the sites will vary with the monitoring objective and can be a selection of river basins, watersheds, irrigations schemes, bore holes, stream monitoring networks or land units.

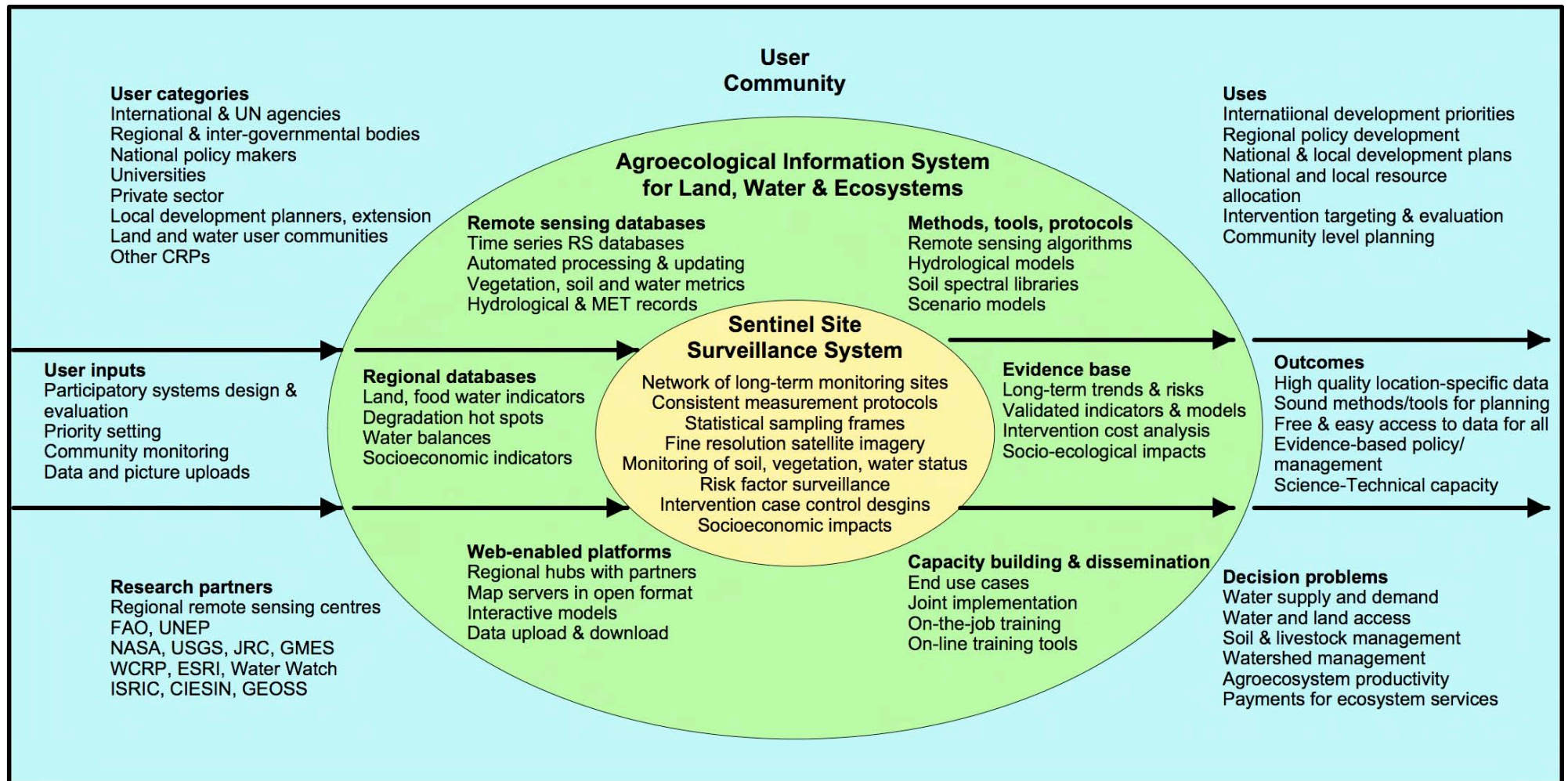
The desired change is for the generation and use of data relevant to policymakers and land and water managers. Our change theory is that this will happen through three main interventions (Figure 8.1):

1. **Focusing data generation efforts and information products on stakeholder decisions that have high value**, by (1) strengthening the use of fields, such as decision sciences, social network analysis and applied information economics, to better understand stakeholder decision processes and prioritize interventions, (2) pinpointing high-value information needs, and (3) involving key stakeholders in product design.
2. **Designing integrated and standardized multi-scale information systems on land and water management to serve regions that are vulnerable to poverty and ecosystem degradation.** Currently, CGIAR and external research in this area is fragmented and yet there are good opportunities to combine information and surveillance concepts, methods, models, databases and map servers, and applying these resources to practical decision problems at common sites. Standards and protocols will help partners contribute data to global information systems and to benefit from them.
3. **Amplifying our ability to deliver high-value information products to our stakeholders** through: (1) providing remote sensing and other information using new open platforms, to create demand and stimulate the provision of more open access data, (2) building the capacity of different stakeholders to contribute to, share and use information products, and (3) building into projects near real-time mechanisms for assessing how products are influencing decisions and changing actions, to expand our knowledge of what is working.

8.5. Where we will work

Agro-ecosystem information systems will be developed globally for some products, but comprehensively at the scale of CGIAR regions: sub-Saharan Africa, Central and West Asia and North Africa, South America, South Asia, East Asia, Southeast Asia, and Central Asia. Our highest-priority target areas are data-poor regions, mainly developing countries of Africa and Asia. Sentinel site surveillance will be conducted at CGIAR benchmark sites, with first priority given to CRP5 SRP sites where land and water management interventions are being tested. Priority will be given to major geographic foci of CRP5: the Mekong, Indus and Ganges plains and hills, the Aral Sea basins (Amu Darya and Syr Darya), the Nile (East Africa), the Limpopo and Zambezi basins, the Volta basin (Niger), and the Andean basins. In addition CRP5 will continue development of the Africa Soil Information Service, covering non-desert portions of sub-Saharan Africa.

Figure 8.1. Information system for Land, Water and Ecosystems



8.6. What we will achieve in the first five years

Within the first three years, key milestones that are not part of existing funded projects include: (1) data portals for agro-ecosystem information systems for Africa, South Asia, Southeast and East Asia, and Latin America established; (2) technical specifications for regional agro-ecosystem and sentinel site data available; (3) existing global and regional spatial databases, including simulated data, compiled according to technical specifications; (4) decision support priorities and use cases established with end users from different categories/scales leading to a defined workflow catalogue; (5) sentinel site data collection in three priority benchmark rivers/basins underway; (6) advances in remote sensing for measuring components of the water balance; and (7) business plan vision for up-scaling data collection and information provisioning through partnerships with development and private-sector organizations.

8.7. What we will achieve in the second five years

Stakeholders from local to global level will have free access to spatial information and decision support tools allowing them to assess land health (the capacity of land to sustain delivery of essential ecosystem services, or the benefits people obtain from ecosystems) and water scarcity and quality, and to evaluate intervention impacts. Agro-ecosystem information systems and sentinel site frameworks and decision support applications will inform land and water management decisions at different scales in five benchmark river basins. Spatially explicit ex post environmental and socioeconomic impact assessment methods and protocols will be mainstreamed in the planning and evaluation all CGIAR funded projects concerning land, water and ecosystem management.

Ultimately in 10–15 years we envisage that all scientifically sound, location-specific data and information in the world of water and land management for agriculture will be freely available to interested stakeholders, leading to increased productivity, sustained environmental benefits and reduced poverty. Remote sensing of the water balance will be in routine operation, well calibrated with ground data. Capacity will be developed among regional and national partners in 15 benchmark river basins in developing countries across Africa, Asia and South America, allowing stakeholders to use improved information tools to plan land and water management interventions in agro-ecosystems and assess impacts at community to regional levels.

8.8. Implementation plan

The work will be done at two levels: (1) agro-ecological information systems at global to regional scales; and (2) sentinel site surveillance systems for monitoring land and water problems and risks and evaluation of interventions. The two levels are hierarchically linked: the sentinel site framework includes observation at nested scales from plot to watershed or household to district, and provides calibration and validation data for models and digital maps applied at regional scales. This SRP supports the other SRPs in CRP5 and other CRPs by providing easy access to data, information, modeling approaches and protocols to help with problem prioritization, intervention targeting, and evaluation of intervention impacts.

Ad hoc approaches to compiling regional agro-ecosystem databases and site characterization will be phased out and characterization will be much better standardized and harmonized across CGIAR regions and sites. CRP5 will play a lead role in coordinating standard CGIAR approaches to regional, research site and landscape characterization, and this process has already begun.

8.8.1. Agro-ecosystem information systems

One of the first tasks will be a systematic information needs analysis, but using protocols developed from new science drawing on areas such as decision analysis, applied information economics and social network analysis. This science-based approach will focus information system products on decisions, information and measurements that have high value in terms of reducing uncertainty of risky decisions for stakeholders at different levels. This area of work will involve developing new partnerships with ARIs in decision sciences.

At the global to regional level, agro-ecological databases will be compiled, standardized and made accessible to researchers and stakeholders through web-based map servers in open access format and for direct download access and viewing in Google Earth. This will allow researchers, managers and the public to use datasets for monitoring, modeling or forecasting with other available models. Specific platforms for tailor-made products will be developed.

The agro-ecological databases will combine time series of high (15–30 meters) and moderate (250–1000 meters) spatial resolution satellite images with near-real-time updating and freely available ancillary data, including socioeconomic data. From the present generation of satellite sensors and those expected to be launched within the next five years, the project will monitor the biophysical properties of the land surfaces, lakes and near-shore areas, including vegetation density and biomass production, soil properties, above- and below-ground carbon storage, and key components of the hydrological cycle such as precipitation, evapotranspiration, soil moisture and infiltration capacity. Ground data and fine resolution imagery will be available from CGIAR sentinel sites (see section 8.8.2.).

The dynamic flows and fluxes of water, carbon and key nutrients ranging from plot scale (1000 m²) to river basins will be approached by a suite of modeling techniques, including simulation models for plot and basin scale, and statistical modeling. This SRP will ensure that models are empirically grounded through the sentinel site surveillance network and emphasize objective validation and uncertainty analysis.

8.8.2. Sentinel site surveillance

Across CGIAR regions, CRP5 will establish sentinel sites in partnership with other CRPs at which ecological and socioeconomic baseline conditions will be measured at the start of the interventions, with monitoring at least every five years, for intervention evaluation and impact assessment. In some cases, sentinel sites will be dispersed networks of measurement sites across river basins (e.g. groundwater monitoring, evapotranspiration flux towers). A standardized protocol will be used across all sites, which can be supplemented with additional measurements of local interest.

In the case of land health, the surveillance methodology will build on the protocols currently applied in the Africa Soil Information Service (AfSIS). Field measurements of vegetation and soil condition are taken using a standardized protocol, which is applied the same way everywhere. Soils sampled from these sites are characterized in the laboratory using low-cost, high-throughput spectroscopic techniques. The protocol includes a carbon stock assessment and information on a range of land health metrics.

The land health surveillance protocol includes assessment of a number of indicators related to hydrological regulation (e.g. flood risk, vegetation cover, topography and soil hydraulic properties), and these protocols will be extended to include other aspects of water health (e.g. water quality, streamflows and groundwater status). Sampling designs that help to better integrate biophysical and socioeconomic information for risk and impact analysis will be further developed, as will ways of linking land health surveillance to agrobiodiversity status and change assessments. Opportunities for combining efforts with other CRPs will be sought, for example with CRP7 (climate change) on household survey protocols for climate adaptation assessment.

Protocols will be designed for statistically rigorous evaluation of interventions designed to improve land and water management (e.g. case-control studies, randomized and non-randomized designs and time series analysis), including socioeconomic and ecological impacts. Scenario modeling (e.g. Grimm et al., 2005, de Fraiture et al., 2007), empirically grounded in the data generated in the sentinel sites, will simulate the trends and effects of key risks on water supply and demand, land health, system productivity, and ecosystem services.

We will carry out meta-analysis of trends and intervention impacts across sites and regions, made possible by the use of standardized protocols and data storage. All synthesized data will be made freely available using the Open Data Commons Attribution License (ODC-BY; www.opendatacommons.org).

8.9. Examples of research questions

Key research questions to be addressed are:

1. What are the critical high-value decisions being made by different stakeholders in water, land and ecosystem management, and what additional information can most reduce uncertainty in those decisions?
2. What are the few key risk factors common to several land and water degradation problems that can form a basis for targeting preventive intervention programs (e.g. exposure of soils, drought, flooding, waterlogging, fire and insecure land tenure)?
3. Which remote sensing and spatial metrics, indicators and scaling techniques are most informative for measuring and monitoring productivity and scarcity and use of land and water resources, and for indicating scope for improvement at different scales? What tools can be produced, from space observations, that allow more balanced water use? Can all water-balance components and uses be measured reliably and monitored remotely? What are the limits to remote sensing of soil functional capacity? Can

measures of agrobiodiversity status and change be linked to the other measures of ecosystem function?

4. What protocols are required for scientifically sound evaluation of impacts of land and water interventions at different scales? What land and water metrics can be used as a basis for reward schemes for environmental services?
5. How can land and water surveillance be incorporated into routine decision-making processes into local participatory land use planning, and into national, regional and international policymaking processes? How can surveillance data guide policy and action on improved agricultural land and water management for the poor? How can land and water surveillance be integrated with human welfare and human health surveillance systems? How can information and communications technology be most efficiently harnessed to this end?
6. What is the most effective way to build capacity in agro-ecosystem information systems and surveillance methods and tools at regional and national levels? What are the limitations to stakeholder use of spatial surveillance information in decision-making for improved land, water and ecosystem management? What incentives and benefit-sharing mechanisms need to be put in place to encourage stakeholders to contribute water data? How can farming communities contribute data to surveillance systems and receive location-specific advice?
7. At regional and global scales, what will be the impact of various land and water changes and interventions under different scenarios of change, using this information as well as simulation- and agent-based modeling?

8.10. Research outputs, outcomes and impact pathways

CRP5 will support the development of spatial information and surveillance hubs by implementing standardized approaches and methods that will serve as platforms for data collection and harmonization, dissemination and capacity building. Each hub, implemented through regional and national partners where possible, will serve a specific region and set of sentinel sites. This SRP will ensure that hubs are uniformly equipped and staffed to implement the standardized procedures. This will include data and map servers linked with high-speed internet connections, soil infrared spectroscopy labs, and scientific and technical staff trained in the latest scientific and technical advances.

The sentinel sites of CRP5 and other CRPs will serve as the principal platforms for engaging end users in the design and testing of information and surveillance systems, dissemination and capacity building. These partners will include the global agricultural monitoring community, regional and national research and extension organizations, universities, natural resource managers, development agencies, and land- and water-user groups, and are described in the individual SRPs. Capacity building in research methods will focus on regional and national researchers, principally through on-the-job training through joint implementation. Business

models for scaling up innovations in information systems will be explored with development partners, agricultural service providers, the private sector and donors.

8.10.1. Research outputs and outcomes

Two examples of Problem Set impact pathways including specific examples of outcomes are provided in Tables 8.1 and 8.2.

Agro-ecosystem information systems outputs

- Analysis of stakeholder decision processes and economic value of information on water and land resources and management, to identify high-value information products.
- Comprehensive, web-enabled agro-ecosystem database and map server for CGIAR regions including surrounding near-shore areas for regional remote sensing monitoring of soil and vegetation conditions and water resources status (also see section 8.8.1).
- Standardized datasets of simulated water data, based on hydrological models and agro-ecosystem databases, at fine spatial resolution for basins and continents.
- Land and water health indicators mapped for CGIAR regions, basins and research sites at nested levels of spatial resolution. New remote sensing techniques for measuring components of the water balance (rainfall, streamflow and groundwater) in partnership with ARIs.
- Innovative approaches to improving use of land and water data, including providing incentives for data sharing, and delivering data to end users via mobile phone technology.
- Increased capacity of regional and national organizations in design and application of environmental information and stronger surveillance systems, including end-user cases, decision profiles and example decision support modules.

Sentinel site surveillance system outputs

- A sentinel site surveillance system consisting of a set of well-characterized, long-term monitoring sites within CGIAR benchmark sites, with standardized databases supporting ecosystem risk assessment and monitoring, intervention targeting and evaluation, and impact assessment.
- Standardized protocols for land, soil and water health surveillance and intervention evaluation, with a web-based infrastructure to collect, centralize and analyze sentinel site data.
- Site-level harmonized baseline of land, soil and socioeconomic conditions at landscape and plot levels for key CGIAR research sites, with monitoring plan.
- Meta-analysis and mapping of land and water management problems, risks and intervention impacts across CGIAR sentinel sites in priority basins, linked to the regional agro-ecosystem databases. Prevalence data and fine resolution digital soil maps on key soil functional problems and risks in sub-Saharan Africa.
- Stronger capacity of regional and national organizations in spatial surveillance and intervention evaluation. This will be achieved through online learning tools, methods, standards, analytical tools, end-user cases, decision support products and joint implementation.

We expect the following outcomes:

- Scientifically sound methods, models and tools for systematic collection, analysis and interpretation of data on land and water trends and risks are being used for the planning, implementation and evaluation of land and water management policy and practice at local to global scales.
- Land and water surveillance systems are adopted as an integral part of decision-making processes on land and water management in regional, national and local systems, resulting in policies and practices that are well targeted to key risks to land, water and ecosystem health.
- A wide range of stakeholders engaged with land and water management, from international and regional policymakers and donors to individual users, contribute and have access to high-quality spatial information and decision support systems, which include benefit-sharing mechanisms to access and use information on land and water resource conditions and trends (from plot to regional scales) and on intervention performance.

Table 8.1. Monitoring longer-term spatial and temporal change in agroecosystems

Issue	Levers of change	Research outputs	Outcomes	Potential impact	Contribution to SRF outcomes
<p>If we are to harmonize agriculture and the environment and manage the impacts of agricultural intensification, we must monitor impacts to provide feedback to policymakers and managers</p>	<ul style="list-style-type: none"> • Ensuring national governments and international agencies see the value in long-term sentinel sites • Commitment from NARES to assist in monitoring and data management • Encouraging free and easy sharing of natural resources data among providers and users. 	<ul style="list-style-type: none"> • A sentinel site surveillance system consisting of a set of well-characterized, long-term monitoring sites • Standardized protocols for land, soil and water health surveillance and intervention evaluation • Site-level harmonized baseline of land, soil and socioeconomic conditions at landscape and plot levels for key CGIAR research sites • Meta-analysis and mapping of land and water management problems, risks and intervention • Online learning tools, methods, standards, analytical tools, end-user cases, and decision support products. 	<ul style="list-style-type: none"> • Capacity of regional and national organizations in spatial surveillance and intervention evaluation strengthened • Feedback to policymakers and managers of appropriate and risky interventions. 	<ul style="list-style-type: none"> • Scientifically sound methods and models for systematic collection, analysis, and interpretation of data on land and water trends and risks used for the planning, implementation, and evaluation of land and water management policy and practice at local to global scales • Policies and practices that are well targeted at key risks to land, water and ecosystem health. 	<p>Increased environmental sustainability in rainfed agro-ecosystems</p> <p>Improved food security at local and regional levels</p> <p>Improved agricultural and NRM policy development</p>

Table 8.2. Harnessing water information to improve management

Issue	Levers of change	Research outputs	Outcomes	Potential impact	Contribution to SRF outcomes
<p>There is a compelling need to make available information on soil water storage (e.g. when to apply fertilizers) to enable farmers to reduce risks and to improve quantification of basin flow and yield.</p>	<ul style="list-style-type: none"> • Development of <i>pro bono</i> partnerships with data providers to enable free access to remote sensing data • Use of mobile phone networks to deliver information • Capacity building in NARES to facilitate improved advice to farmers on how to respond to information. 	<ul style="list-style-type: none"> • High-resolution water-storage assessments • Basin flow models better calibrated for land use • Guidelines for fertilizer management under given soil-water scenarios • Drought risk assessments • Standardized datasets of simulated water data, based on hydrological models and agro-ecosystem databases, at fine spatial resolution for basins and continents. 	<ul style="list-style-type: none"> • Water surveillance systems are adopted as an integral part of decision-making processes on land and water management in regional, national and local systems • Delivery to farmers of water information by mobile phone • Improved drought prediction. 	<ul style="list-style-type: none"> • Smallholders increase yields and livelihoods because of reduced risks • Improved water yield forecasting assists water allocation planning • Impact of drought reduced through more opportunity to foresee consequence and plan mitigation strategies at government level. 	<p>Improved food security at local and regional levels</p> <p>Improved livelihoods for smallholders</p> <p>Increased environmental sustainability in rainfed agro-ecosystems</p>

8.10.2. End-user engagement and dissemination

The regional and sentinel site framework will engage stakeholders in design and assessment through several mechanisms. First, rigorous survey and scientific analysis of decision processes will guide prioritization of information products, and end-user engagement will be taken through all stages of development. Second, study designs, metrics and monitoring processes will be designed so as to acquire more rigorous and immediate feedback on the effectiveness of information products than has been achieved in the past. A variety of communication channels will be used to communicate information to potential users including policymakers, local communities, agricultural extension workers, land-use planners, wildlife managers, ecosystem managers, research scientists and climate modelers.

Innovation in dissemination of information through Enterprise 2.0 (social media) tools, and crowdsourcing (outsourcing tasks to a large group of people or a community) of data capture through mobile phone technology will be explored. Rapid development of smartphones will make it feasible to send and share maps and pictures.

Sustainability of this initiative will be achieved through embedding surveillance and spatial impact assessment in regional, national and local planning processes through capacity building at various levels. This will include interfacing and building business models for up-scaling information services with development partners and agricultural input and information providers. These models will contain appropriate benefit-sharing mechanisms for information providers from developing countries. The focus of CGIAR capacity building will be on training-of-trainers, including regional- and national-level scientists, development partners, educators and students, through joint implementation, student supervision and development of online tools. Online tools include self-help spatial information, methods guidelines, standards, materials for university curricula and statistical workflows.

8.10.3. Links to others CRPs

Links to other CRPs will be at two levels. Agro-ecosystem information systems, models and information products will be improved and made more relevant through collaborative work with other CRPs; and joint implementation of sentinel site surveillance will help identify intervention priorities and assist with evaluation of the larger hydrologic and landscape implications of field-scale interventions. Examples are given below.

CRP1 (Integrated agricultural systems)

Improve spatial information for targeting agricultural systems for the poor and jointly monitored sentinel sites for landscape-level evaluation of improved systems.

CRP2 (Policies, institutions, and markets)

Jointly develop policy priorities to reduce risks to land and water health based on surveillance data and involve policymakers in the design of information and surveillance systems. Improve spatial data sets on policy, market and institutional indicators.

CRP3 (Wheat; maize; rice; roots, tubers and bananas; grain legumes; dryland cereals; and livestock and fish)

Orient spatial information on agro-ecosystem conditions for input to crop models and improve spatial information on crop productivity and production potential.

CRP4 (Agriculture for improved nutrition and health)

Improve spatial decision support for safe wastewater use and nutritional aspects of increased productivity.

CRP6 (Forests, trees and agroforestry)

Joint analysis of surveillance information on land and water health risks in forestry and agroforestry systems and co-develop improved hydrological models for tree-based systems. Joint design of CRP5 sentinel sites within CRP6 proposed sentinel landscapes.

CRP7 (Climate change, agriculture and food security)

Improve information on carbon stocks in agro-ecosystems and develop strategies for climate change adaptation. Shared household/village survey protocols. Input climate change projections in agro-ecosystem resilience and scenario analysis.

8.11. Research partners

Existing spatial databases will be integrated by drawing on partnerships within and outside the CGIAR, including the CGIAR Consortium for Spatial Information (CSI), the Africa Soil Information Service (www.africasoils.net), HarvestChoice (<http://harvestchoice.org/>), World Climate Research Programme (WCRP), FAO (GLADIS, AQUASTAT), ESRI, Water Watch, ISRIC, CEISIN, and GEOSS.

Strategic research partnerships with centers of excellence in the North will build on existing CGIAR links. For example, collaboration with the Center for International Earth Science Information Network and the Earth Institute at Columbia University through AfSIS will facilitate access to satellite imagery and IT infrastructural developments. Planning is underway with a global consortium led by the Bill & Melinda Gates Foundation and Conservation International to design a global agricultural monitoring framework. National programs will be key partners in compiling time series hydrological and meteorological data.

Partnerships for engaging different stakeholder groups and for the constructing cases will be developed through the sentinel sites, including national institutions and development organizations. Partnerships for capacity building will also use the sentinel sites as nodes, but also include regional centers engaged in land and water management (e.g. RCMRD in Eastern Africa, AGRIMET in West Africa). Details of other partners are shown in Table 8.1.

Table 8.3. Partnerships for the Information Systems SRP

Region/ basin	Core research	Implementation and outreach
Limpopo and Zambezi	National Agricultural Research (IIAM), Mozambique; CSIR (South Africa), University of Malawi, Bunda College Malawi; Forestry Research Institute of Malawi-Forestry;	Southern African Development Community; Department of Agricultural Extension Services and Department of Agricultural Research and the Land Resources Conservation Department from the Ministry of Agriculture and Food Security, Malawi; WRC (South Africa); CARE International, Tanzania; UNEP; Mzuzu University, Malawi; Ministry of Natural Resources, Energy and Environment, Malawi; Total Land Care and National Association of Smallholder Farmers.
Nile	Addis Ababa University, Ethiopia; University of Göttingen, Germany; University of Makerere, Uganda; University of Nairobi, Kenya; Mekelle University, Ethiopia; Kenya Agricultural Research Institute (KARI), Kenya; Regional Center for Mapping of Resources for Development (RCMRD), Nairobi, Kenya; National Agricultural Research Organization (NARO), Uganda; WaterWatch (Netherlands), IHE (Netherlands); Cornell University, USA; Bahir Dar University (Ethiopia)	Aga Khan Foundation; Ministry of Environment and Natural Resources, Kenya; Rwanda Agriculture Development Authority (RADA), Rwanda; Nile Basin Initiative (NBI)
Volta and Niger	AGRIMET, West Africa; Centre National de Recherche Agronomique (INRA), Cote D'Ivoire; Center for Scientific and Industrial Research (CSIR), GHANA; Institut d' Economie Rurale (IER), Mali; Institute for Environment and Agricultural Research (INERA), Burkina Faso; Water Research Institute – CSIR, Ghana, ZEF- Bonn;	Mars Inc., USA, Volta Basin Authority (VBA) ; Water Research Commission (WRC)- Ghana

Mekong	Chinese Academy of Agricultural Sciences (CAAS), China Mongolian Society for Range Management; National Agricultural and forestry Research Institute (NAFRI)- Laos; CSIRO- Australia; Xishuangbanna Tropical Botanic Garden (XTBG-CAS); Kunming Institute of Botany (KIB-CAS); Northwest University (NWU), Vietnam	Ministry of Water Resources and Meteorology, Cambodia; WREI- Water Resources and Environment Institute, Laos; Yunnan Department of Agriculture Yunnan and Department of Forestry, China; Ministry of Agriculture and Forestry, Laos; Department of Forestry of Luang Prabang Province, Laos; Ministry of Agriculture and Rural Development, Vietnam; Department of Agriculture and Rural Development (DARD) of Son La, and Dien Bien provinces, Vietnam; Department of Forestry, Myanmar; Yezin Forestry University, Myanmar
Indus and Ganges	National Remote Sensing Centre, India; ICIMOD, ICAR, Pakistan Agricultural Research Council, IITM- Pune, India, IWM (Bangladesh); WWF-India	Ministry of Water Resources, Ganga Water Authority (GWA India), WAPDA (Pakistan); WWF-India
Amu Darya and Syr Darya	National Hydrometeorological Service (SIC), Uzbekistan; The Institute of Hydrogeology and Engineering Geology, Tashkent	GTZ, WUAs in Ferghana Valley
Tigris and Euphrates	Arab Center for the Studies of Arid Zones and dry lands (ACSAD); International Center for Biosaline Agriculture (ICBA);	(In development)
Andes Basins	Embrapa (Brazil); INIA (Peru); IIAP (Peru); INIAP (Ecuador); Corpoica (Colombia); CIAT-Santa Cruz (Bolivia)	GIZ (regional); Ministry of Environment (Peru); UNALM (Peru); UNU (Peru); UFPA (Brazil); UFRA (Brazil); FVPP (Brazil); IPHAE (Bolivia); UNIAMAZONIA (Colombia)
AfSIS- SSA (in addition to Limpopo and Zambezi; Nile;	MTT Agrifood Finland; Sokoine University of Agriculture, Tanzania; University of Columbia, USA; Tanzanian Agricultural Research Institutes; Macaulay Land Use Research Institute;	Alliance for a Green Revolution in Africa (AGRA); Bill & Melinda Gates Foundation, USA; Conservation International, USA; WWF, USA; Wajibu MS, Kenya; Ministries of Agriculture in 42 sub-Saharan Africa

and Volta and Niger basin partners)		countries; Bill & Melinda Gates Foundation; Center for International Earth Science Information Network (CIESIN), Columbia University, USA;
Global (apply to most basins)	Colorado State University; Michigan State University; University of Florida, USA; University of Hohenheim, Germany; United States Geological Survey (USGS); National Aeronautics and Space Administration (NASA), USA; Global Water Systems Project (GWSP)	Agilent Inc, UK; Bruker Optics and Bruker AXS, Germany & South Africa; Google Inc, USA; Perkin Elmer, UK; Faculty of Geo-Information Science and Earth Observation (ITC); Food and Agricultural Organisation (FAO), Rome, Italy; Global Earth Observation System of Systems (GEOSS), Switzerland; Global Monitoring for Environment and Security (GMES); World Soil Information (ISRIC), Netherlands; Joint Research Centre of the European Commission (JRC); United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); World Bank; World Climate Research Program (WCRP)