Nexus Dialogue on Water Infrastructure Solutions

Nexus Dialogue Workshop

Bogota, Colombia, 24-26 September 2013

Workshop Report

Contents

Executive Summary

Water, energy and food systems are inter-connected and have become increasingly more complex and dependent upon one another. As a result, a disturbance in one system can destabilise the others - highlighting the need for a 'Nexus-Based Approach'. This requires the water, energy and food sectors to engage in a dialogue and deliberative analysis of river basins, looking for solutions to optimise the inter-dependencies and support the equitable and sustainable allocation of natural resources while balancing environmental, social and economic issues.

The Nexus Dialogue on Water Infrastructure Solutions held the second in a series of three regional "Anchor" workshops (for Africa, Latin America and Asia) in Bogota, Colombia on 24-26 September 2013. Participants were drawn from across Latin America and from the water, energy and food sectors. The Nexus Dialogue workshop provided an opportunity to identify the problems and solutions to secure water, energy and food security both across and within Latin American river basins.

The aim of the Latin America Nexus Dialogue workshop was to build on the outputs from the Africa workshop and focus on the optimisation of solutions for water, energy and food security in the region. Workshop participants were encouraged to identify where the barriers to optimisation exist, and look at where and how these have been overcome.

The objectives of the workshop were to:

- Learn from participants about the challenges in applying and integrating best practice, nexus based approaches in river basins for water, energy and food security;
- Support participants in establishing integrated roadmaps to plan for strategic investment in technology and infrastructure solutions (built and natural) for water, energy and food security
- Motivate participants to take practical steps towards implementing water, energy and food nexus thinking and practices in their basins.

A number of emergent themes ran through the workshop, these included:

- ***Technology and infrastructure solutions***
  - Will they work? Will they ever really be implemented at the scale needed?
- ***Institutional and sectoral silos***
  - Can they be overcome?
  - How to get better engagement by the energy sector in decision making?
- ***Infrastructure optimization***
  - How does this happen?
  - What needs to be done to make it happen?
  - What are the triggers?
  - Are there places where this is happening?

Participants from the Bogota workshop were encouraged to build new coalitions and partnerships for follow-up action in technology, demonstration, investments in built and natural water infrastructure and national-level dialogues on policy and implementation.

The third regional workshop in Asia (March 2014) will build on the outputs of the Latin America Nexus Dialogue workshop. It will focus on the identifying barriers to the implementation of optimised solutions and where and how these have been overcome.

1. Introduction

IUCN (the International Union for Conservation of Nature) and IWA (the International Water Association) are collaborating on a joint initiative to address competing water demands in river basins. The '*Nexus Dialogue on Water Infrastructure Solutions'* is a call to action to those leading transformations in water infrastructure planning, financing and operation. With a continued increase in water abstractions and use from growing populations and more irregular patterns of water availability due to climate change, the pressure on water supplies is rising.

Increasing urbanisation and economic growth provide significant benefits, but also pose a range of challenges especially for water quantity and quality. Water, energy and food security rely on water infrastructure. Recognition of the closely bound interaction between water, energy and food – the nexus - has led to new demands for water infrastructure and technology solutions.

To address competing water needs cities and utilities need to diversify water supply options from a single source to a portfolio of supplies. They will need to optimise water infrastructure for multiple purposes, including investing in watersheds as natural infrastructure to work in concert with built infrastructure which supplies water to cities and industry. This will require cities and industries to engage effectively and efficiently in river basin management and support the equitable negotiation of water allocations across users.

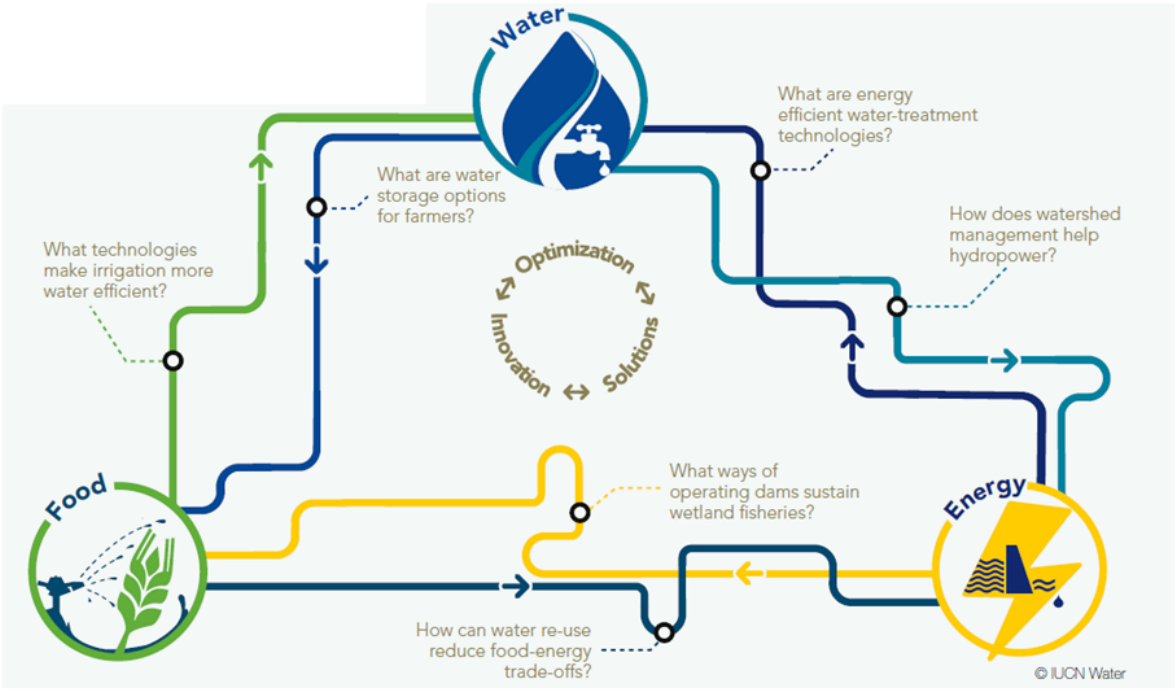


Figure 1: **Interactions of water, energy and food - the nexus**

The '*Nexus Dialogue on Water Infrastructure Solutions'* is a major component of the Basins of the Future programme. It is a call to action to those leading transformations in water infrastructure planning, financing and operation. The Nexus Dialogue is future-focused, examining how engineered and nature-based water infrastructure and technology are currently being used and can be made more functional and sustainable (Figure 1), to secure water, energy generation and food production while balancing environmental, social and economic issues.

The Dialogue will help to identify and share water infrastructure and technology solutions for the water-energy-food security nexus. More complete and broad cross-sectoral thinking is required to deal with the challenges around water, energy and food production efficiencies, trade-offs, and cross-sectoral impacts. The Dialogue will provide a global platform (Figure 2) for sharing experiences, lessons, tools and guidelines on how portfolios of water infrastructure and technologies can address nexus challenges.

Figure 2: **Global Dialogue Platform**

The Dialogue is designed to build a common understanding of innovative planning, management and operational approaches that provide shared benefits across sectors. A series of three regional workshops – in Africa, Latin America and Asia – will bring together innovators and thought leaders from the water, food and energy sectors (Figure 3).

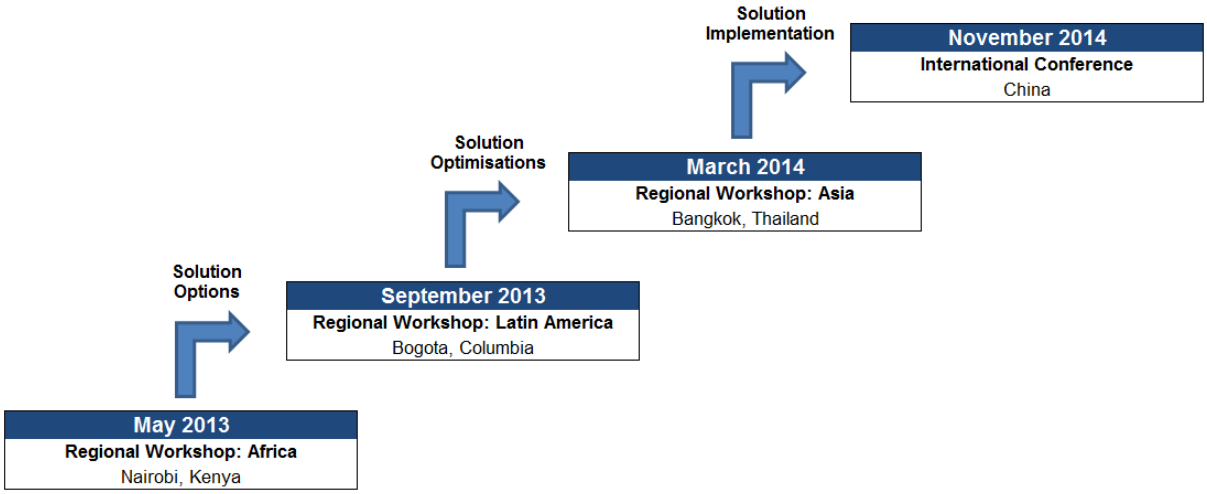


Figure 3: **The Nexus Dialogue**

The workshops will build on 'best-practice' success stories in water infrastructure operation and innovation to create a shared, cross-sectoral vision that combines best available technology, know-how and experiences. The Nexus Dialogue will culminate in the 2014 International Conference on Water, Energy and Food in China. The conference will be a major milestone in creating new pathways for water infrastructure planning, investments and operations to meet the integrated challenge of water, food and energy security.

2. Latin American Nexus Dialogue Workshop Objectives

The objectives of the Latin American Nexus Dialogue workshop were to:

- Learn from participants about the challenges in applying and integrating best practice, nexus based approaches in river basins for water, energy and food security;
- Support participants in establishing integrated roadmaps to plan for strategic investment in technology and infrastructure solutions (built and natural) for water, energy and food security
- Motivate participants to take practical steps towards implementing water, energy and food nexus thinking and practices in their basins.

The workshop was organised over 3 days incorporating the following interactive sessions (see Section 9.1 *Appendix One* for full agenda details):

Day 1

- **Session 1:** Case Study - Huasco River Basin
- **Session 2:** Trajectory to 2050 - Global context and Latin American context
- **Session 3:** Nexus 2050 Vision - Fictional River Basin case study
- **Session 4:** Fictional River Basin - Problems, Causes and Solutions
- **Session 5:** Milestones to Nexus 2050 Vision
- **Session 6:** Solution Optimization

Day 2

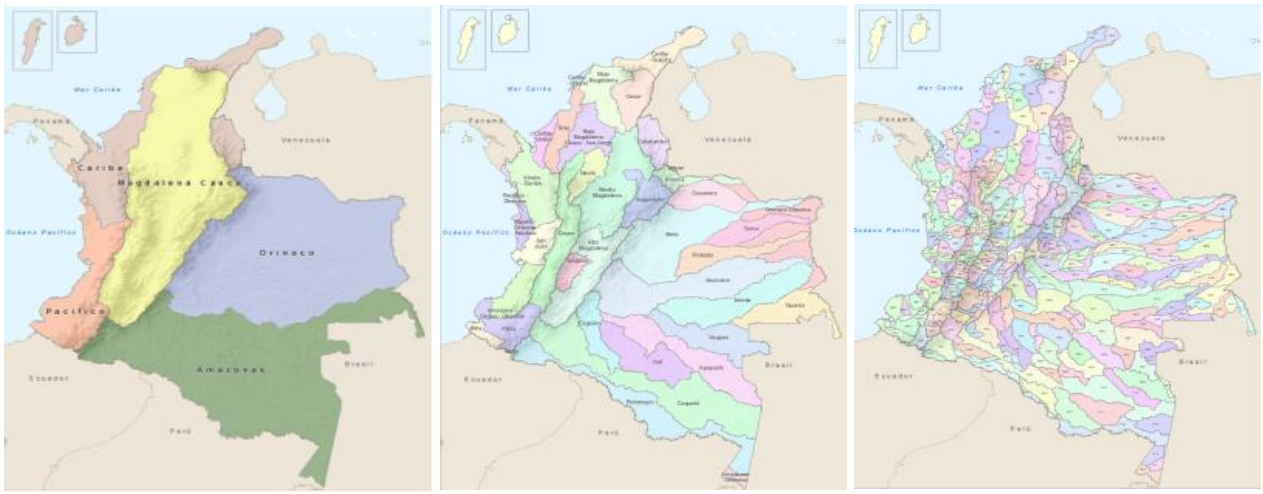
- **Session 7:** Team Presentations - on fictional river basin Nexus 2050 optimized solutions
- **Session 8:** Plenary
- **Session 9:** Latin American river basins - Problems, Causes and Solutions
- **Session 10:** Latin American river basins - Nexus 2050 Milestones
- **Session 11:** Latin American river basins - Nexus 2050 Solutions Optimisation

Day 3

- **Session 12:** Plenary
- **Session 13:** Prepare Latin American river basin presentation reports
- **Session 14:** Deliver Latin American river basin presentation reports

3. Keynote Address

David Roman (Department of Integrated Water Resources Management, Ministry of Environment, Colombia) advised workshop participants that public policy on water in Colombia is taking a cross-sectoral perspective to help mitigate conflict over water resources by providing, regulation, cultural and supporting services. There are distinct levels of water resource management planning in Colombia that are based on hydrographic areas consisting of 5 major river basins, 41 sub-basin zones; and 309 sub basin areas (Figure 4).



Colombian River Basins | Colombian sub-basin zones | Colombian sub-basin areas

Figure 4: **Hydrographic zones in Colombia**

The 5 main river basins are the level at which strategic river basin planning occurs. Instrumentation and monitoring occurs within the 41 sub-basin hydrographic zones; and watershed planning and management takes place at the level of the 309 sub-basin hydrographic areas.

The *Integrated Management of Water Resources* document compiles all relevant data to inform and influence government policy on sustainable water resources management, through the conservation of ecosystem services and consideration of water as an economic development factor. Agricultural

use is a key priority, along with energy, household use and industrial use. Determinations are made according to what proportion is needed by different sectors and what level of water quality is fit for use. All Colombian institutions have a role to play in water resource management at national, regional and local levels. Each has defined roles and responsibilities within a defined water governance process.

4. The Huasco River Basin Case Study

Victor Gonzalez (Technical Manager, Junta de Vigilancia del Río Huasco) advised participants that the Junta de Vigilancia del Río Huasco (JVRH) in Chile was established in 2005 and manages water for 2,500 users. Water rights in Chile are provided freely to develop economic activities. These rights (or stocks) provide a quantitative definition of water use.

The Huasco River is in the Atacama Region of Chile. Atacama is one of the driest places on Earth, yet maintaining the flow of the Huasco River is crucial. The river sustains livelihoods and farming communities, export businesses and ecosystems - all dependent on the river's flow. Fed by Andean glaciers on the Chile-Argentina border, the Huasco River is formed by the confluence of the Del Carmen and Del Transito tributaries.

There are three reservoirs in the basin. The Santa Juana Reservoir was built in 1995 to store water for irrigation needs. But it has not been without controversy. Residents in the basin have been concerned the Huasco River may suffer the same fate as the neighbouring Copiapó River, which after receiving no rainfall over the last 10 years has dried up due to mining and agricultural activity in the region.

In 2007 management of the Santa Juana Reservoir was transferred from private ownership to JVRH, who now establish user allocation rules for each season, based on water availability. A USD 60 million 'Water Fund' has been established in cooperation with a mining company to improve agricultural and irrigation infrastructure over 20 years. 18 million USD have been invested in channel, irrigation and hydro-electric power infrastructure.

5. Trajectory to 2050

Camilo Muñoz Trochez (Programmes Officer, Latin America and the Caribbean, IWA) outlined how delivering water uses energy, energy production uses water, agriculture uses both and modern societies need all three. Water, land and energy systems are interconnected, with complex interactions (the nexus). We all depend upon natural resources for our water, energy and food security.

The world population is predicted to grow from 7 billion in 2010 to over 9 billion in 2050. The global demand for water (a finite resource) is projected to increase to more than 55% current levels by 2050; food consumption is projected to increase by 60%; and energy demand is projected to increase by 80%. This rising global population is becoming increasingly urban. Today, one in two people on the planet live in a city. Every second, the urban population grows by 2 people.

As global resource demands increase with rising populations and expectations, they will need to be serviced with water, energy and food against a backdrop of climate change. Competition will increase across the various uses of these natural resources for agriculture, industry, energy and ecosystems.

Recent extremes of droughts and floods in Latin America and the Caribbean have forced recognition of the closely bound interaction and interconnections between water, energy and food. Disturbance and change in one system can destabilize the others. Development of innovative water infrastructure and technology that optimise and address the interdependencies of water, energy and food will become ever more important.

6. Fictional River Basin - Case Study

Workshop participants were organised into mixed groups and presented with a 'fictional' river basin case study. The fictional river basin was presented with specific issues and opportunities (see Section 10.4 *Appendix Four*). Participants were then provided with the '***Nexus 2050 Vision'*** for the fictional river basin[1].

Each group was asked to consider the problems, their causes and potential solutions (see Section 10.6 *Appendix Six* for the solution template). Priority solutions were chosen by a system of voting, where each participant was asked to select their five most preferred solutions from each group.

Each group was then asked to take their most popular solutions for further analysis. For each solution, the groups were asked to identify what were the milestones to be achieved at 5 year intervals (see Section 10.8 *Appendix Eight* for the solution timeline template) to achieve the Nexus 2050 Vision.

For every 5 year milestone each group was asked to consider:

- Obstacles
- Who is involved
- Tools and resources
- Success indicators

Based on this exercise, each group was then asked to come up with a series of recommendations for the fictional river basin (see Section 10.7 *Appendix Seven* for the overall list of suggested solution recommendations)

7. Latin American River Basins

Following the activities undertaken in the mixed group sessions on the fictional river basin in Day 1, workshop participants were next organised according to the following Latin American river basin affiliations:

- Santa River Basin, Peru
- Sao Marcos River Basin (a sub-basin of the Paranaiba basin), Brazil
- Magdalena River Basin, Colombia
- Reventazón River Basin, Costa Rica

Within their river basin groups, participants were then asked to apply the '*Nexus 2050 Vision'* methodology from Day 1.

7.1. Santa River Basin, Peru

7.1.1. Background

The Santa River is 316 kilometres long, rising in the Cordillera Blanca and ultimately descending to the Pacific Ocean. The Santa River Basin (Figure 5) is an important economic area for the Ancash region of Peru. It contains gold mines, hydropower dams, irrigation systems growing export crops and provides for the 1.8 million people living along the river.

[1] Coordinated, multi-purpose infrastructure solutions providing water, energy and food security by 2050

Glaciers in the Cordillera Blanca make up around 70% of annual flow in the Santa River. The Santa River Basin has seen as much as a 22% reduction in glacial mass (the blue sections in Figure 5) over the last 40 years. The glacial mass declined from 507 km^2 in 1970 to 387 km^2 in 1999. This is considered to be the early sign of the impacts of global climate change on terrestrial hydrology.

Glacial retreat will have profound implications on future hydrologic regimes in systems that are managed to meet multiple objectives, including domestic water supplies, irrigation and hydropower production (which provides over 70% of electricity demands in Peru). Flows from glaciers in the region are expected to increase over the next 25 to 40 years as they melt. But this increase in flow will decline from 2050 onwards as the glaciers reduce in size. This could put the Santa River and the ecosystem services provided by the river under extreme pressure, especially during the dry season when 70-90% of the river flow is glacier fed.

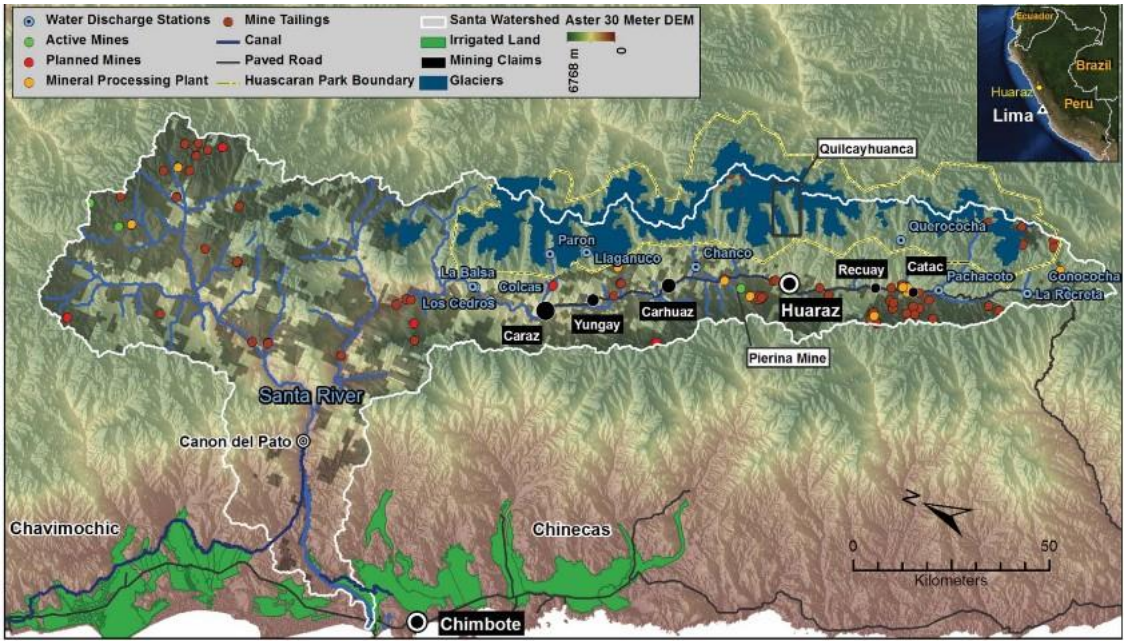


Figure 5: **The Santa River Basin**

The Huascaran National Park Authority is concerned about poor land use practices, over-grazing and soil degradation, affecting biodiversity, soil slope stability and species diversity and abundance. However, farmers are mainly concerned with the amount of sediment and the impact on canals and agricultural equipment. Water quality is often mentioned as the common concern amongst stakeholders. Mining activities, dam tailings, agricultural run-off, lack of wastewater treatment and direct solid waste discharge into the Santa make protecting the river a common challenge.

7.1.2. Problems and causes

The primary problems and their causes identified for the Santa River Basin were:

- No fish in river - pollution from legacy toxic mine tailings
- Less water available - glacial retreat and increasing demand
- Rising water table – salinization of agricultural land:
  - Flood irrigation practices
  - Low water pricing
  - Lack of funds for precision agriculture
  - Reduction in ecosystem resilience

- Conflict between agriculture and energy sectors over access to water - inadequate intuitional arrangements for equitable resource allocation
- Limited energy production in peak hours and dry seasons - prioritisation bias towards agriculture
- Sedimentation of hydro power turbines - poor land management – over grazing

7.1.3. Solutions

The preferred solution package was outlined as:

- **Technology**
  - Increase water storage infrastructure (natural and built)
  - Establish basin wide monitoring system
  - Increase water efficiency and demand management through development and application of river basin information system
- **Institutional and cross sectoral coordination**
  - Initiate cross sectoral dialogue by establishing a river basin commission
  - Develop and deliver strategic river basin IWRM plan review and update every 5 years
- **Incentive for change**
  - Establish case for change through pilots across river basin to demonstrate case for amplification
  - Establish Centre of Excellence to enable and enhance innovation and improve science, policy and practice

7.1.4. Obstacles to implementation

The main obstacles to implementation were identified as:

- Low water pricing
- Lack of political will
- Engaging other sectors (e.g. mining, tourism)
- Overlapping jurisdictional responsibilities

7.1.5. Long term action plan

The long-term action plan milestones to help achieve the Nexus 2050 vision for the Santa River Basin (see section 10.9 *Appendix Nine*) were identified as:

- **By 2015:**
  - Stakeholder Analysis
  - Joint regional agreement to initiate pilot case studies
  - River Basin Commission established
- **By 2020:**
  - Case studies complete
  - Strategic river basin management plan drafted

  - Roles and responsibilities defined
- **By 2025:**
  - Natural infrastructure being managed for water storage
  - Start build of more localised water storage infrastructure
  - Land and water management legislation introduced
  - Review strategic river basin management plan
- **By 2030:**
  - Review Strategic Plan
- **By 2035:**
  - Fish return to Rio Santa
  - Review Strategic Plan

7.1.6. Recommendations

Recommendations to achieve the Santa River Basin 2050 Nexus Vision included:

- **Economics and finance**
  - Engage donor sector in pilots and case for change
  - National and local government and stakeholders financed basin commission
  - Centre of Excellence for research and innovation financed by National and local government, stakeholders and donor community
- **Technology and infrastructure (natural and built)**
  - Manage natural infrastructure for water storage
  - Develop decentralized water throughout basin
  - Establish monitoring network and basin information systems
- **Governance**
  - Establish river basin commission
  - People and capacity
  - Establish Centre of Excellence for research and innovation

7.2. São Marcos River Basin, Brazil

7.2.1. Background

A major challenge for river basin management in Brazil is how to address stakeholder power asymmetry that arises from the dominance of land owners. The agriculture sector is powerful and responsible for development. However, as there is no agriculture sector master plan, development is not coordinated. In an attempt to overcome there was a move to develop a single water management system. The river basin commissions are a central part of this process, developing water resources plans to address the power asymmetry. There is now a move to incorporate sectoral plans into water resources plans to enable cross sectoral involvement in river basin management.

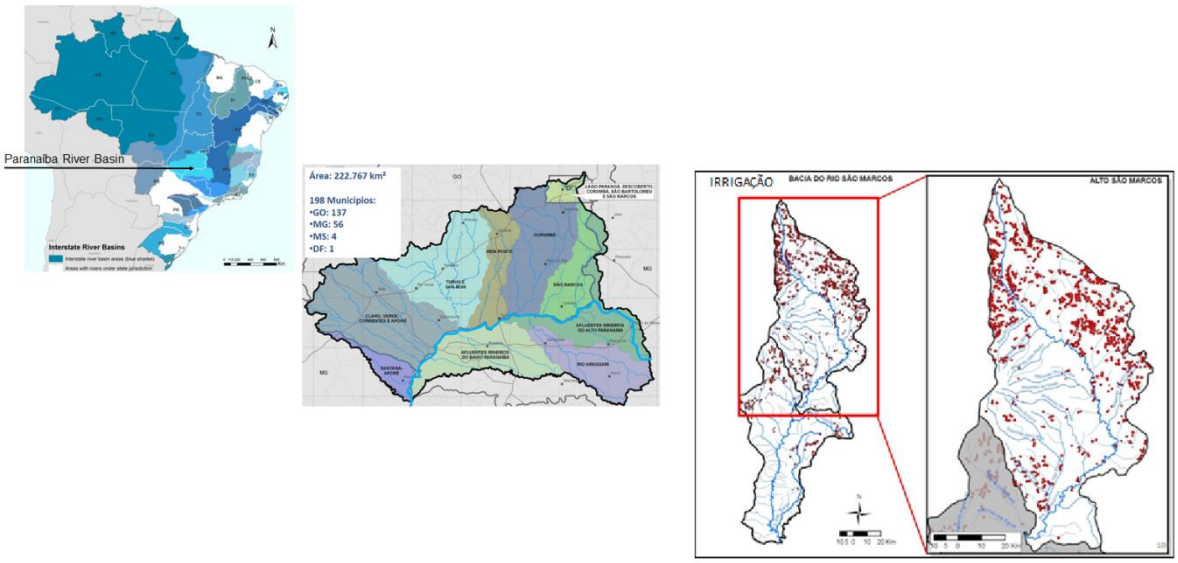


Figure 6: **The São Marcos River**

The São Marcos is a river of Goiás state in central Brazil. It is a tributary of the Paranaíba River (Figure 6), which it joins in the reservoir created by Emborcação Dam. As elsewhere in Brazil, conflict between water for agriculture irrigation and water for energy generation is a key issue in the São Marcos River Basin

7.2.2. Problems and causes

The main problem identified in the Sao Marcos River Basin was outlined as:

- Conflict between irrigation and energy generation – institutions and their capacity

7.2.3. Solutions

The preferred solution package was outlined as:

- Decentralised dry season water storage for irrigation
- Greater farmer coooperation to improve water use efficiency
- Control point network for water monitoring across the basin
- Charge for water use
- Influence planned dam (Mundo Novo) to focus on multi-pupose use and operation with downstream hydropower dam (Batalha)
- Mobilise and build the abilities of the Water Management System (Federal and State level)

7.2.4. Obstacles to implementation

The main obstacles to implementation were identified as:

- Political will
- Lack of trust between stakeholders and resitance to change
- Finance for a water monitoring surveillance network and information management system
- Capacity of institutions to cope with the speed of growth, stability of national institutions, and unstable state level water institutions

7.2.5. Long term action plan

The long-term action plan milestones to help achieve the Nexus 2050 vision for the Sao Marco River Basin (see section 10.9 *Appendix Nine*) were identified as:

- River Basin Commission will implement a charge for water use for irrigation (2015)
- Federal and two State Water Agencies establish water monitoring system (2020)
- Decentralised dry season water storage for irrigation (pilot 2020 – to scale by 2025/30)
- Improve farmer organisations and implement Cooperative Water Licensing (2020)
- Pilot projects to improve water use efficiency for agriculture (pilot 2020 – to scale by 2025/30)

7.2.6. Recommendations

Recommendations to achieve the Sao Marco River Basin 2050 Nexus Vision included:

- **Economics and finance**
  - Implement water charging
  - Provide finance to implement plans
- **Technology and infrastructure (natural and built)**
  - Irrigation efficiency to improve production
  - Water monitoring network system
  - Decentralized dry season storage
  - Influencing design of the Mundo Novo dam
- **Governance**
  - Establish governance mechanisms to support and enable the National Water Management System (NWMS) to influence cross-sectoral engagement
  - Need national policy decision to enforce the NWMS to be fully implemented
- **People and capacity**
  - Training and development for farmers in new technologies for irrigation and farming practice
  - Technical water specialists to improve water management, mainly at the State institutional level

7.3. Magdalena River Basin, Colombia

7.3.1. Background

Regional environmental councils have been established for the major river basins in Colombia. At a smaller sale, sub-basin area councils have been set up that allow the inclusion of more local stakeholders.

Figure 7: **The Magdalena River Basin**

Some of the key issues in the Magdalena River Basin include:

- Impacts downstream of hydroelectric projects
- Lack of agreement and regulations on ecological flow
- Vulnerability of surface water sources to extreme events: El Nino, La Nina
- Competition between uses during water deficit times
- Lack of comprehensive planning

7.3.2. Problems and causes

The main problems identified in the Magdalena River Basin were outlined as:

- Water resource stress – competing uses – water, energy and food demands
- Lack of inter-sectoral planning
- Contamination of water resources - urbanisation, agriculture, mining and lack of capacity for control by authorities

7.3.3. Solutions

The preferred solution package was outlined as:

- **Institutions and cross coordination**

  - Creation of the Consejo Ambiental Regional de la Cuenca del Rio Magdalena (CARMAC) Regional Environmental Council of the Magdalena River Basin and it's link to national planning structures for energy, water and agriculture
  - Strengthening of regional environmental authorities
- **Technology and Infrastructure**
  - Improve efficiency of water use by the energy and agriculture sectors
  - Smart grid to optimise power generation including for water and flows
  - Role of Green infrastructure in protecting the water resources and impact of diverse uses
  - Sustainable land use solutions based on climate projections
- **Incentives for change**
  - Eliminate subsidies and charge a tariff which reflects the real social and environmental cost of the water – especially by large-scale users
  - Economic assessments to define best use of land and efficient investment
  - Mobilise investment in ecological restoration (Payment for Ecosystem Services)
  - Effective investment of concession fees

7.3.4. Obstacles to implementation

The main obstacles to implementation were identified as:

- Lack of inter-sectoral coordination
- Resistance to change
- Lack of coherence in public policy
- Short term political vision
- Lack of political will linked to economic interests
- Technical capacity of institutions who regulate
- Effective use of financial resources

7.3.5. Long term action plan

The long-term action plan milestones to help achieve the Nexus 2050 vision for the Magdalena River Basin (see section 10.9 *Appendix Nine*) were identified as:

- Creation of the CARMAC
- Institutional strengthening around planning, economic efficiency and technical capacities
- Integration of Magdalena Basin Plan into sectoral plans and National Development Plans
- National Monitoring Plan functioning to provide information about supply, demand, quality and economic assessment
- Full integration of Risk Management Plan into the River Basin Plan

7.3.6. Recommendations

Recommendations to achieve the Magdalena River Basin 2050 Nexus Vision included:

- **Economics and finance**
  - include resources in the National Development Plans to address the Magdalena River Basin
  - Economic incentives for those who use environmentally friendly practices in the agriculture and energy sectors
- **Technology and infrastructure (natural and built)**
  - Future smart grid to optimise hydropower, agricultural co-generation and solar power, including for water management and flows
  - Take advantage of the huge natural infrastructure opportunities in the basin
  - Quality control for wastewater in small urban centres
  - Monitoring of supply, demand and quality
- **Governance**
  - Implementation of existing legal framework and instruments
- **People and capacity**
  - Strengthening of existing institutions in financial, technical and capacity

7.4. Reventazón River Basin, Costa Rica

7.4.1. Background

In Costa Rica energy generation is largely based on renewable resources. There are three large hydroelectric projects in the Reventazón River Basin (Figure 8). Together they generate up to 25% of country's energy. All of the reservoirs depend on the upper part of the Reventazón river basin.

There have been a number of problems and conflicts with farmers in the Reventazón River Basin over water use for irrigation in competition with water use for energy production. This is because the basin has been prioritized for hydropower development. This conflict is compounded by poor land management in the upper catchment causing soil erosion and sedimentation of hydro-power turbines.

In response to these issues a river basin management programme was initiated, with different plans directed at agriculture and forestry. In 2000, a basin commission was created to promote more cross sector dialogue and better interaction across sectors.

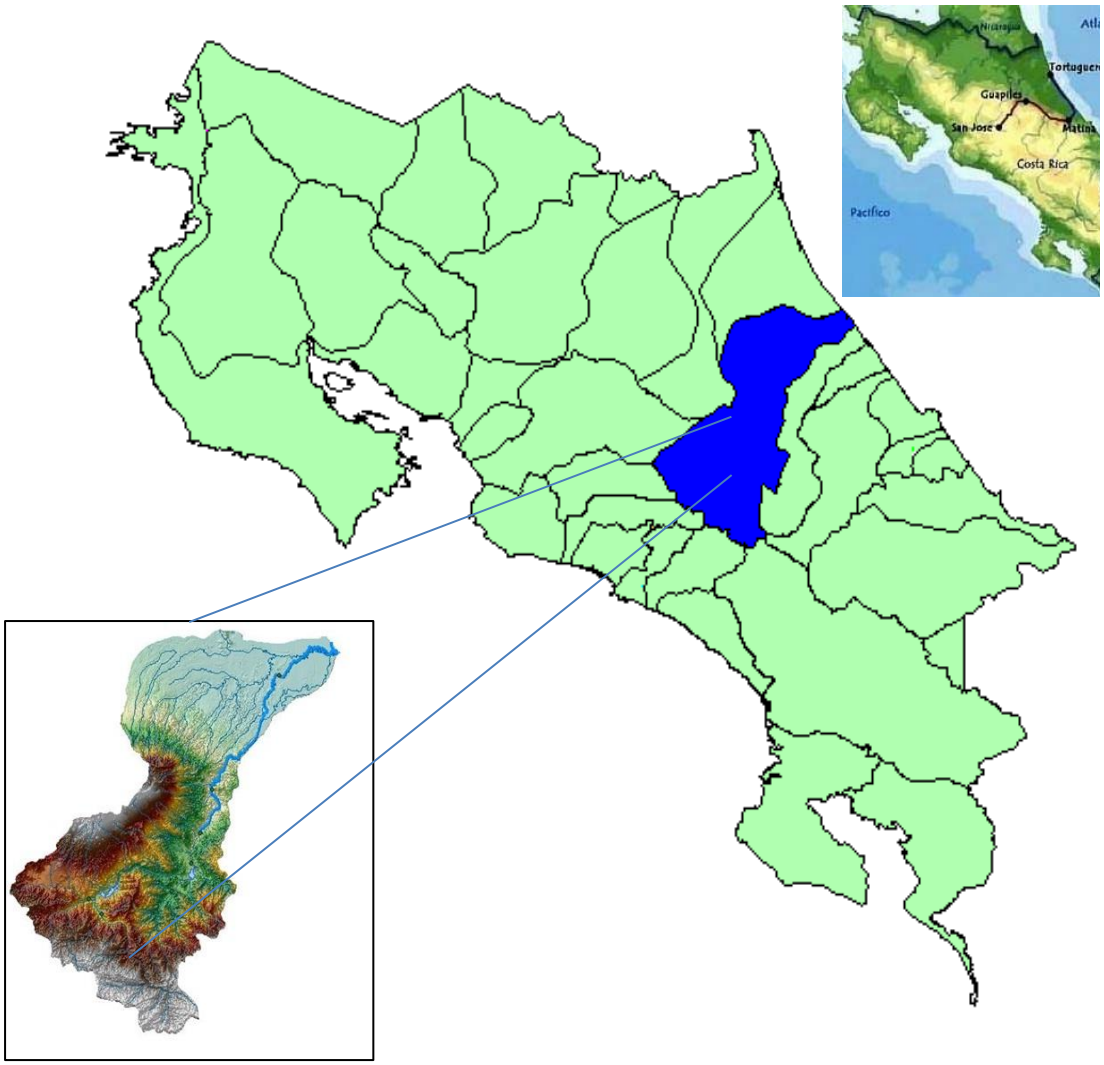


Figure 8: **The Reventazón River Basin**

7.4.2. Problems and causes

The main problems in the Reventazón River Basin were recognised as:

- Decreased water availability between June and April - weather, climate change, La Nina and El Nino impacts on water supply
  - Low capacity of reservoirs
  - Low efficiency of irrigation systems
  - Increases in food production using water for energy generation
- Erosion problems affects reservoirs - lack of wastewater treatment
  - Poor agricultural practices
  - Peak demand of agricultural exports during dry season
- Conflict between energy and food production
  - Legislation gives priority to energy

7.4.3. Solutions

The preferred solution package was outlined as:

- **Institutions and cross coordination**
  - Empower the River Basin Commission and Council of basin so that it can influence decision-making
  - Establish a new Water Act
  - Establish the River Basin as the watershed planning unit
- **Technology and Infrastructure**
  - Construction of treatment plants in cities in conjunction with bio filters, wetlands and bio-digesters in rural areas and farm level
  - Small reservoirs of water for agriculture-processing of the agricultural products to be less reliance on export of fresh product in dry season
- **Incentives for change**
  - Set requirements of participation by the use of efficient technologies.
  - Possible participation in certification of proper use of water resources systems.

7.4.4. Obstacles to implementation

The main obstacles to implementation were identified as:

- Resistance to change
- Lack of infrastructure for transport of water for reuse for irrigation.
- Lack of financial resources
- Legal obstacles and resistance of affected parties by reservoirs.
- Complexity of the administrative procedures for accessing existing financial resources

7.4.5. Long term action plan

Several solutions were identified as a way forward in the Revantazon Basin. One of the key issues is around deteriorating water quality so there is planning in place to construct wastewater treatment plants across the basin. The discussion indicated that there is opportunity to make waste water treatment plants more sustainable by producing biogas and reusing water for agriculture. Some of the obstacles to address included the cultural resistance around the reuse of wastewater for irrigation and use of waste for biogas production, as well as the lack of infrastructure for reusing water. This would require investment in appropriate technology, infrastructure to transport reused water for irrigation and training incentives to enable the production of biogas. Another solution set was developing food processing plants to ensure less dependence on exporting fresh produce. The processing plants plant could provide waste products to be used in biogas production.

Small reservoirs are needed to sustain agricultural production, especially as hydropower production is increased. This could be potentially financed through water funds although there are complex administrative processes to access these funds. There also needs to be agreements in place with farmers on placing of reservoirs and ensure that there is any compensation of land that is lost. Technical support can be provided by government and NGOs to increase irrigation efficiency using the micro-reservoirs.

Although there is a basin commission in place, there is a need for this institution to be empowered and able to influence decisions. This can be improved through the introduction of a new water law (which is in the process of being developed) and using the basin as a planning unit for development of water, food and energy. For the water law to be effective there needs to be demonstration of its application. This can be initiated by education and awareness of the water law and the role and responsibilities of river basin stakeholders.

The long-term action plan milestones to help achieve the Nexus 2050 vision for the Reventazón River Basin (see section 10.9 *Appendix Nine*) were identified as:

- Design of treatment plants for production of energy (biogas) and reuse of water in irrigation.
- Construction of treatment plant of the city of Carthage by 2020, Turrialba by 2030, and Guácimo by 2035
- Feasibility study and agreement with interest groups for construction of micro-reservoirs to use agricultural priority areas by 2025.

- Use of high efficiency technology for irrigation and agricultural production as a requirement for participation.
- Study of market, feasibility and construction by 2020 for agricultural processing plants
- Integrated use of waste for energy and fertilizers production by 2030.
- New law on waters by 2020
- Creation of a water fund.
- Empowerment of the Basin Council Committee with a supporting strategic River Basin Management Plan and Action Plan

7.4.6. Recommendations

Specific recommendations to achieve the Reventazón River Basin 2050 Nexus Vision included:

- **Economics and finance**
  - Take advantage of the resources of the waters of Costa Rica Canyon.
  - Look for funds to finance projects.
- **Science and technology**
  - Design infrastructure for multiple use
  - Use of more efficient production and irrigation technology
- **Governance**
  - Updated legal framework incorporating the vision of inter-sectoral planning and multiple use of resources.
  - Promote the use of the river basin as unit of planning by the central Government and the municipalities
- **People and capacity**
  - Implement formal and informal education programmes that include the Nexus vision
  - Establish induction, technical training, advice and follow-up programmes for the inhabitants of the river basin.

8. Major Emerging Themes

Some of the major themes to emerge from within the Latin American Nexus Dialogue workshop included:

- ***Technology and infrastructure solutions***
  - Will they work? Will they ever really be implemented at the scale needed?
- ***Institutional and sectoral silos***
  - Can they be overcome?
  - How to get better engagement by the energy sector in decision making?
- ***Infrastructure optimization***
  - How does this happen?
  - What needs to be done to make it happen?
  - What are the triggers?
  - Are there places where this is happening?

Areas of consensus across all groups:

- Is the basin commission the right institution for delivering Nexus based solutions?
- Information sharing
- Technologies – real time flow management
- Agreements – across borders and sectors
- Overcoming resistance
- Trying to find ways for coherent institutional set-up
- Importance of capacity and capability building

Specific issues raised by individual groups:

- Trade-offs – linking technology options, to get beyond old confrontations
- Financing the process which needs significant investment
- Importance of an adaptive management approach across sectors
- Need to consider risks and costs from the perspective of different sectors
- Sharing of water and energy
- Importance of governance – across all levels

9. Communications

Workshop participants were advised of the different ways to stay engaged with the Nexus Dialogue on Water Infrastructure Solutions and how to share stories and contribute solutions, which include:

- To visit the **Nexus Dialogue Website**: www.waternexussolutions.org
- To contribute **tools or case studies**: tools.waternexussolutions.org/ibis/nexus/eng/toolbox
- To join in discussions via our **LinkedIn group**: www.linkedin.com/groups/Infrastructure-Solutions-Water-Energy-Food-4853909?home=&gid=4853909&trk=anet_ug_hm
- To keep up to date via our **social media** links Facebook and Twitter (@WaterNexus)
- To download photos from the workshop, please access the Flickr **photo gallery**: www.flickr.com/photos/iucnweb/sets/72157633761657250/

- To share **Blog stories** please go to: www.waternexussolutions.org/1xj/media.html

10. Next Steps

Participants from the Bogota workshop will be encouraged to build new coalitions and partnerships for follow-up action in technology, demonstration, investments in built and natural water infrastructure, and national-level dialogues on policy and implementation.

The Asia Nexus Dialogue workshop will be held in Bangkok, Thailand (March 2014) and will build on the outputs of the Latin America Nexus Dialogue workshop.

The Nexus Dialogue will culminate in the 2014 International Conference on Water, Energy and Food in China. The conference will feature water infrastructure and technology solutions for optimization across the nexus. The conference will be a major milestone in creating new pathways for water infrastructure planning, investments and operations to meet the integrated challenge of water, energy and food security.

11. Appendices

11.1 Appendix One – Workshop Agenda Day 1

Time	Session	Summary
09:00-09:30	**Arrival and registration**	
09:30-10:00	**Welcome and introductions**	• Outline purpose of the Nexus Dialogue • Nexus communication platforms • Introductions and expectations
10:00-10:30	**Keynote address:** To be confirmed	• Introduction to the Latin America Nexus Dialogue Workshop
10:30-11:00	**Session 1:** Case Study	• Huasco River Basin case study
11:00-11:15	**Break**	
11:15-11:30	**Session 2 :** Trajectory to 2050	• Global context • Latin American context
11:30-11:45	**Plenary**	• Questions & Answers
11:45-12:00	**Session 3 :** Nexus 2050 Vision	• Fictional River Basin case study
12:00-12:30	**Plenary**	• Questions & Answers
12:30-13:30	**Lunch**	
13:30-15:00	**Session 4:** Fictional River Basin	• Facilitated mixed team session to agree the problems, causes and solutions
15:00-15:15	**Break**	
15:15-16:30	**Session 5:** Milestones to Nexus 2050 Vision	• Facilitated mixed team session to timeline solution delivery milestones
16:30-17:30	**Session 6:** Solution Optimization	• Facilitated mixed team session on what are the necessary infrastructure optimisations
17:30	**Day 1 Close**	

17:30-19:00	**Reception:** Drinks and Nibbles	• Selected case study presentations by some workshop participants

11.2 Appendix Two – Workshop Agenda Day 2

Time	Session	Summary
09:00-09:15	**Arrival and refreshments**	
09:15-10:30	**Session 7**: Team Presentations	• Mixed team presentations on their Nexus 2050 optimized solutions for the fictional river basin
10:30-11:00	**Session 8: Plenary** Day 1 Synopsis	• Synopsis of Day 1 activities and introduction to Day 2
11:00-11:15	**Break**	
11.15-12:30	**Session 9:** Latin American river basins Problem, Causes and Solutions	• Facilitated river basin team session to agree river basin problems, causes and solutions
12:30-13.30	**Lunch**	
13.30-15:00	**Session 10:** Latin American river basins Nexus 2050 Milestones	• Facilitated river basin team session to timeline solution delivery milestones and achieve the Nexus 2050 Vision
15:00-15.15	**Break**	
15.15-17.00	**Session 11:** Latin American river basins Nexus 2050 Solutions Optimisation	• Facilitated river basin team session to prioritise infrastructure solutions
17:00	**Day 2 Close**	
19.30	**Workshop Dinner**	

11.3 Appendix Three – Workshop Agenda Day 3

Time	Session	Summary
09:00-09:15	**Arrival and refreshments**	
09:15-09:45	Session 12: Plenary Day 3 Synopsis and communication tools	• Synopsis of Day 2 activities • Communication tools
09.45-12:00	Session 13: Prepare basin presentation reports:	• Facilitated river basin team session to determine follow up commitments – How will you use the information from the workshop? – Do you need support in follow up? What type of support? – Do you need help in linking with the relevant people?
12:00-13:00	**Lunch**	
13:00-15:00	Session 14: Deliver basin presentations:	• Becoming Nexus Ambassadors • Building Nexus Partnerships
15:00	**Close**	

11.4 Appendix Four – Fictional Case Study – The Disparate River Basin

The Disparate River Basin (Figure 10.4) covers an area of about 125,000 km^2 and is occupied by two countries: Konfundesia and Akinonia. It is framed by the Tarambana Mountain Range to the north, the Fathomless Sea to the south, the Menhir Desert to the west and a mixture of swamps and highlands to the east. In the centre of the basin lies a large lake connected to the Disparate River and remaining segments of a large rainforest, the Shrouded Forest.

The Disparate River is the principal river of the basin (500 km) with headwaters on the slopes of Pinguimanjaro Volcano (in the Tarambana Mountains) and flowing south and east to the Fathomless Sea. The tributaries of Disparate River are the Sambara (350 km) Mumbara (230 km) and Tarambana River. See Table 1 below for more information.

Table 1: Disparate River Basin Statistics

	Konfendesia	**Akinonia**
Population	Population (2013) - 14.5 million Population growth rate – 1.6% Urbanization – 60% of inhabitants live in urban areas	Population (2013) - 9.5 million Population growth rate – 2% Urbanization – 45% of inhabitants live in urban areas
Economy	GDP - 8000 USD per capita Economy is based on agriculture, livestock, fishing and tourism	GDP - 6000 USD per capita Economy relies on raw materials (mining and agricultural outputs) and tourism
Energy	- 70% of energy is from hydropower from Gudi Dam, located on the upper Disparate (200MWH) - 0.5 % Biofuels but growing - 1% alternative energy – solar and wind - Remaining energy produced by thermal power – coal, gas, oil, biomass etc - Exploring increased solar and nuclear power	- 80% of energy is hydroelectric, and 50% of energy is provided by Papyrus Dam on the lower Disparate - Papyrus Dam is being enlarged to increase its generating capacity Upper Sambara dam project is planning construction 75 km upstream from Styropolis. - 0.5% of energy from wind power but growing (in energy policy, and 2 pilot wind farms on the Seals Peninsula) - Remaining energy produced by thermal power – e.g. coal, gas, oil, biomass
Agriculture	- Main crops are of cotton, wheat, potatoes, tobacco, and sugarcane - Sugarcane being also used for biofuel production (especially on the middle reach of the Disparate)	- Main crops are oilseeds, tobacco, fruit, and ornamental plants, all for export. - Timber production is a large activity - Increasing soybean production due to strong demand on the world market. But resulting in increasing monocultures and dominance of agribusiness leading to marginalization of small scale farmers.
Water	- Water use – 800m^3/inhabitant/year - Annual Renewable Water Resources (km^3/yr) – 900 km^3/year	- Water use - 500m^3/inhabitant/year - Annual Renewable Water Resources (km^3/yr) – 600 km^3/year
Natural resources	- Hydropower, fishing, agriculture, livestock, mining resources are being developed	- Mining (silver, copper, and gold deposits in Upper Sambara region), hydropower, timber, agriculture, wetlands
Government	- Constitutional monarchy and there is a decentralized authority across five autonomous regions: Harpooners, Metis, Upper Mumbara, Chimaeras, and Tarambana	- Republic with six regions: Upper Sambara, Selachian, Gloria, Paladins, Victory and Sovereignty.

Disparate River Basin Current and Emerging Issues

The Disparate River Basin is rich in natural and mineral wealth. On the one hand, Konfundesia, is a developing country with a strong purchasing power, it has a diversified economy based on agriculture, livestock, fishing and tourism; on the other end, the economy of Akinonia relies only on the production of agricultural outputs, mining and tourism. Both countries need to increase their energy generation capacity and improve water management to meet the rising demand from industry and population growth in urban areas.

The government of Akinonia claims that its economy has been directly and negatively affected by Konfundesia's appropriation of water and demands changes in water management practices and a more equitable distribution. Environmental groups, representatives of the tourism and industrial sectors (particularly the energy sector), as well as civil society associations representing local and indigenous communities are all urging the governments of Akinonia and Konfundesia to find long term solutions to the problems deriving from the reduction in the flows of the Disparate River.

Some key issues facing the countries include: increasing water shocks including water scarcity and flooding in the basin especially in semi-arid and arid areas; growing urbanization, slum areas, unplanned developments; and iinstitutional inertia and technical barriers. There on-going investment in water infrastructure within both countries, see Table 2 below, which outlines some of the main issues.

Konfundesia and Akinonia have agreed to establish a 'Joint Commission' to achieve the Nexus 2050 Vision for the river basin.

Table 2: Infrastructure development issues in the Disparate River Basin

Infrastructure or development	Main issues
Tarpon Canal entirely within Konfundesian territory and runs parallel to the border with Akinonia	- Canal has reduced flows downstream and compromises operation of Papyrus Dam in Akinonia, impacts port and lower basin ecosystem - Reduced flows due to water diversion for irrigation in upper and middle catchment, and operation of Gudi Dam – has affected economy due to decreased agricultural outputs as a result of less water availability - Ships in canal are causing pollution and introducing invasive species - Dredging to deepen Astonishment Bay and allow navigation of vessels to the port of Estambay has increased conflict
Edara Dam – Upper Mumbara River (constructed by Konfundesia)	- Construction of dam has led to a number of criticisms by the government of Akinonia, which has lodged a formal protest demanding that the project be definitively halted.
Upper Sambara Dam – being planned by Akinoia on the upper Sambara River upstream from the city of Styropolis	- pre-feasibility study has been approved, and loan from the World Bank to finance construction. - Konfundesia say dam will irremediably damage the ecosystem of the Adonis Swamp impacting farming and livestock keeping, and calls for the project to be suspended. - Environmental groups and other sectors of civil society in both Konfundesia and Akinonia have taken similar positions.
Papyrus Dam –by Akinoia	Government of Konfundesia submitted a formal complaint: - concern due to flooding resulting from the filling of its reservoir, severely restricting the operation of the Tarpon Canal. - Concern that the reservoir could alter the boundary between the two states due to a significant change in the fluvial (and lacustrine) geography of the region. - Environment conducive to the breeding of insects that transmit diseases such as malaria, dengue and yellow fever.
Biofuels – in Konfundesia's Metis Autonomous Region	- The Metis region is one of the dryest parts of the country - Biofuels require irrigation of large areas of cropland and affects the flows of the Mumbara River. - Development of biofuels sector is reducing available land for livestock grazing

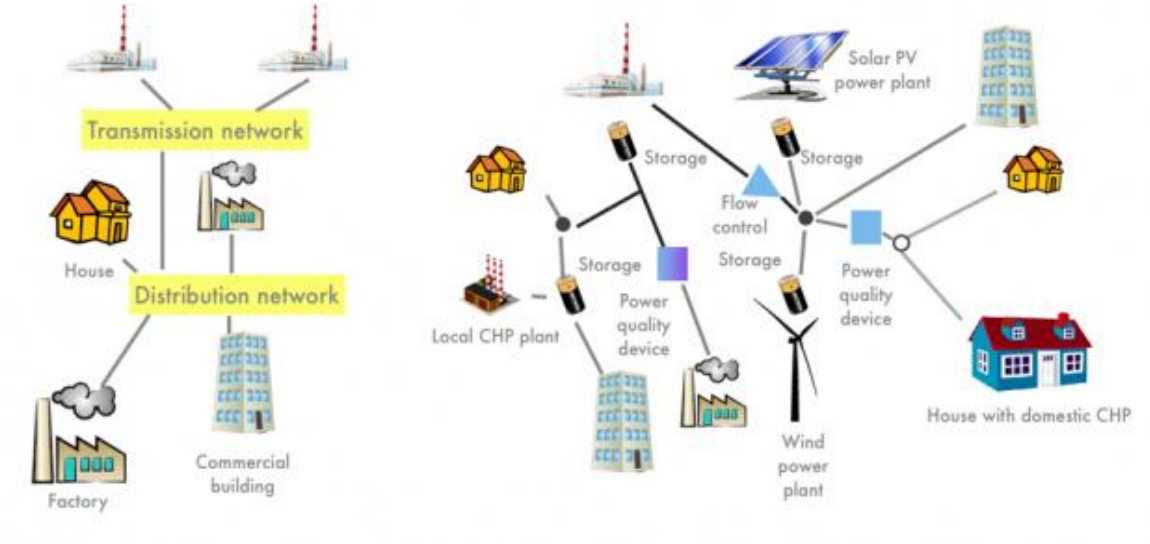
Disparate River Basin - Nexus 2050 Vision (*or what the future will look like?*)

Technology and Infrastructure

Energy

Energy across the basin will be diversified. There will be expansion of energy developments such as hydropower as well as alternative sources of energy (windpower, solar and biofuels) for increasing demand. Hydroelectric power will be a significant part of the energy mix, however there will be increased investment in micro-hydro installations and other technology which will lead to greater decentralization that is economically viable (Figure 1). There will also be investment in improving energy efficiency.

Figure 1: Centralisation versus Decentralisation



Source: Farrell 2012

The energy sector will have an evolving business plan to ensure environmental, economic and social sustainability and encourage investment from the private sector. All energy developments will consider changing climate conditions, water availability and demographics. There will also be investment in skill development and education to improve innovation in the energy sector, as well as ensuring that there are people to operate the energy projects.

Development of dam infrastructure will include the following considerations:

- Include financial sector in the development of strategies and plans, not just at financed stages
- Transparency and participatory planning
- Regional regulation and good political support
- Cross-sectoral and intergovernmental cooperation and consultation at each stage of dam development
- Legal binding agreements on sharing of water resources

Land Use Management

There is a clear recognition of the pressures certain human activities can place on the environment and the importance of identifying and zoning suitable land for suitable uses to minimise impacts. Land within the river basin is zoned by its capability and land use suitability, according to soil type geology, topography and proximity to sensitive water bodies.

Agriculture

The agriculture sector will invest in improving water efficiency and reusing wastewater. There will be a focus on developing technologies throughout the food value chain (from growing crops through processing to consumers) that are water efficient. Although improving food production will be a

priority, there will be dedicated capacity building to improve the skills and outputs of small scale farmers and entrepreneurs through the agricultural value chain (from seeds to plate). This will be in cooperation with larger agro-business.

Water supply

There will be increased water demand resulting in exploitation of alternative sources of water including surface water, groundwater, re-used water, desalinated water and harvested rainwater. There will be a move towards using water fit for purpose. So high-quality water is provided for drinking, but stormwater and recycled water of a lower quality can be used for irrigation and in the case if cities to water parks and gardens.

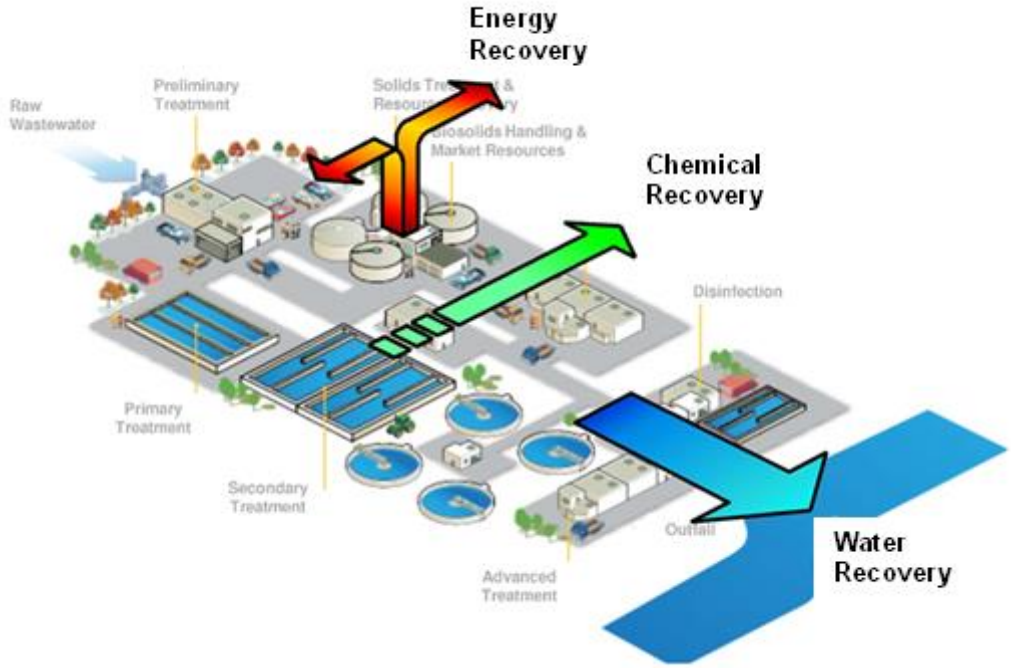
Small scale storage will be developed to provide alternative water supply for agriculture as well as other sectors (industrial and drinking water). This will be an important buffer to changes in rainfall and increased demands for food production. A wider range of options of storage will be explored and applied as appropriate including large scale reservoirs, small ponds, groundwater, and water harvesting through soil moisture storage. Development of water storage will include the following:

- Financing facilities that can enable development and construction of storage at different scales (village to city)
- Build in local knowledge into designs, to complement the best technologies
- Set-up appropriate decentralized institutional arrangements, but working across multiple levels with national coordination , including to regional level
- Build technical and institutional capacities for networks of water storage, which includes continuous learning, supported by assessments and communications

Resource recovery

There will be increasing application of resource recovery between sectors – for example from wastewater which can provide water, energy and nutrients to be used in agriculture and other sectors (Figure 2); or runoff from agriculture is treated and re-used in irrigation or food processing.

Figure 2: Resource Recovery

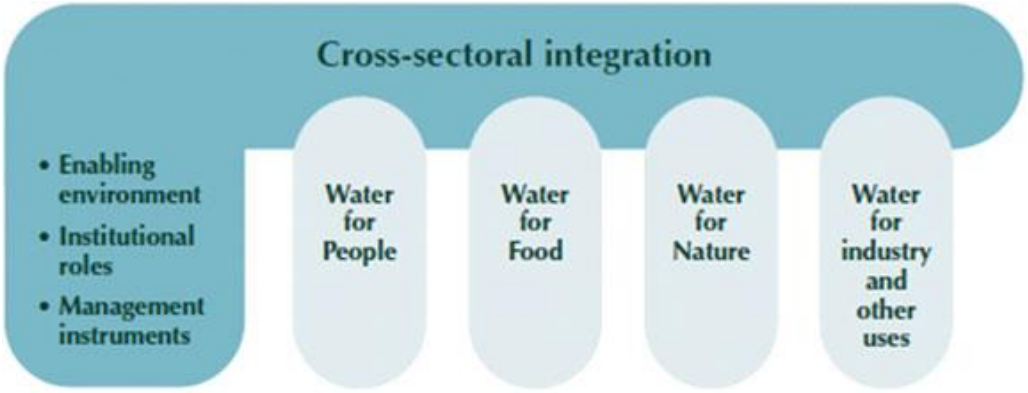


Source: Umble 2013

Institutional and cross sector coordination

The basin will establish a joint cooperation agreement for a river basin mandate enabling development of a nexus water allocation framework that incorporates environmental flows (water for all sectors including ecosystems).

Figure 3: Coordinated cross-sectoral resource management



Source: GWP 2000

There will be a cohesive multi-sectoral approach from policy to planning to delivery (Figure 3). There will be investment in the development of decision support tools that identify how resources can be shared and what are the trade-offs. Financing options for nexus based projects and new technologies will be through a variety of sources (government, private sector, development partners, social enterprise).

Figure 10.4 – The Disparate River Basin

11.5 Appendix Five – List of Workshop Participants

Name	Organisation
Alejandro Calvache	The Nature Conservancy
Bento Godoy Neto	Comitê da Bacia Hidrográfica do Rio Paranaíba - Brazil
Bernal Soto	Sistema Nacional de Riego y Avenamiento - Costa Rica
Camilo Munoz Trochez	IWA
Carla Friedrich	UNEP
Carolina Carias	GWP
Charles Rowley	Oxfam
David Roman	Department of Integrated Water Resources Management, Colombia
Eugenia Ponce de Leon Chaux	Asesora en temas de Política y Legislación Ambiental
Gustavo Calvo Domingo	Instituto Costarricense de Electricidad ICE - Costa Rica
Jorge Medina Esquivel	Basin Council Operative Director – Mexico
Julio Velasquez	Duke Energy Egenor – Peru
Kelly Kryc	US STATE Department
Leonardo Saenz	Conservation International
Mario Aguirre	IUCN
Patricia Bejarano	Conservation International
Pol Adarve Panicot	Abeinsa/Abengoa
Rocio Cordoba	IUCN
Sergio Ayrimoraes	ANA - Brazil
Simon Cook	CGIAR
Solomon Abel	CDM Smith
Sophie Mueller	GIZ
Victor Gonzales	Junta de Vigilancia Huasco – Chile
Vitor Alberto Simão	Associação dos Irrigantes de Goiás, Brazil
Wilfredo Echevarría	National Water Authority, Peru
Yulieth Coronel	Ministry of Housing, Colombia

11.6 Appendix Six – Fictional River Basin Solutions Template

Pressure:			
	Problem	**Cause**	**Solution**
Water - Food			
Food - Energy			
Energy - Water			

11.7 Appendix Seven – Fictional River Basin Solution Recommendations

Economics and finance

- Ministry of Finance should be involved in the process throughout
- Valuation of water and analyzing the cost of not-acting on the information for medium term planning and growth and development
- Establish Public-Private Partnerships, provide enabling environment for the donor community, commit state funding to invest in the process.
- Increase in the system of payment of the fee for use of water, by incorporating its real value

Technology and infrastructure (natural and built)

- Hydrological information system critical for decision making
- Design and built diversified multi-purpose infrastructure (using natural solutions where possible)
- Modernization of irrigation systems
- Improve hydraulic infrastructure and flow measurement systems

Governance

- Ensure long term political buy-in
- Different hierarchies of governance approaches to be used
- Ensure action between institutions with limited sectoral commitments and influence
- Nexus Institutional Framework established, supported by Legislation, Regulations, Policy, and bi-lateral international Agreements.
- Strengthening of social participation in a catchment-based approach, supported by formal recognition of the river basin commission

People and capacity

- Share capacity between countries and sectors
- Use independent, science, academic, innovative institutions and networks to support and inform the process
- Institutional and workforce capacity building to support adaptive management for nexus optimization
- Training of producers in new technologies
- Technical advice and support
- Training to government agencies and administrators of the basin

11.8 Appendix Eight – Solutions Timeline Template

Solution:								
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Milestone								
Obstacles								
Who is involved								
Tools & resources								
Success indicators								

11.9 Appendix Nine – River Basin Solution Timelines

Santa River Basin

	2015	2020	2025	2030	2035	2040	2045	2050
Milestone	Stakeholder Analysis Joint regional agreement to initiate pilot case studies	Case studies complete 5 -10 year strategic river basin plan drafted Roles and responsibilities defined	Natural infrastructure being managed for water storage Start build of more localised water storage infrastructure Groundwater abstraction Land and water management legislation introduced	Review Strategic Plan	Fish return to Rio Santa Review Strategic Plan	Review Strategic Plan	Review Strategic Plan	Review Strategic Plan
Who	Basin staekholders Multi-level governments Donors	National and sub national governments Adaptive men						
Tools & Resources	Inventory of water resources Basin monitoring and evaluation infratructure Consultants NGOs IUCN	Basin water information system Adaptive management planning tool Nexus decision support system Cross sectoral communication strategy						
Obstacles	Political will Engaging other sectors (mining, tourism) Overlapping rurisdictional responsibilities	Low water pricing						
Indicators	Joint framework agreement Basin Commission esteblished Cross sectoral involvement in river restoration plans	Case studies lessons learned Increased awareness and understanding Need for water pricing agreed Strategic 5-10 year objectives set Center of excellence	Water pricing and land use zoning regulations Improved land management Reduced soil erosion Increased water availability Plan reviewed - objectives updated	Improved water quality Plan reviewed - objectives updated	Plan reviewed - objectives updated	Plan reviewed - objectives updated	Plan reviewed - objectives updated	Plan reviewed - objectives updated

Sao Marcos River Basin, Brazil

	2015	2020	2025	2030	2035	2040	2045	2050
Milestone	New energy transmission lines in place Batalha dam online (-10% capacity) Agreement between 2 States and Federal level on water monitoring points Pilot projects for water quantity and quality	Pilots of decentralised water storage for irrigation Water user fee in place for agriculture and industrial users Irrigation policy developed and applied - linked to licensing for use and abstraction and linked to	Irrigation policy fully in place and reviewed	Green houses for year round vegetable production in place at a viable commercial scale				Coordinated multi-purpose infrastructure providing solutions for water-energy-food security
Who	River Basin Commission 3 Water Agencies (2 x state level and one Federal level) Ministry of Energy - co-owners of FURNAS (its a PPP) Farmers operate in sub-basin Commissions	EMBRAPA Farmers and Cooperatives 3 x water agencies River Basin Commission Other government agencies - Agriculture, Infrastructure	Financers of dams and decentralised storage and modern irrigation approaches Agricultural companies trailing new crops and approaches Rural banks					
Tools & Resources	The sustainability of the water fee is agreed by farmers and their business plans can be developed Capacity building transition period for Basin Commission to take over full role, supported by 3 x water agencies	Institutional capacity already exists Financial resources exist Work with FURNAS on feasibility ToR for new proposed dam (Mundo Novo) Building capacity at State level for irrigation	Ensure Mundo Novo dam is multipurpose and not just for dry season storage for Batalha dam					
Obstacles	Speed of growth hard to keep up with	FURNAS - energy, its private - irrigation sector is public, and private. Communication between them does not really happen						
Indicators	Farmer cooperatives in place MoU between Federal and 2 x State level water agencies to agree on an action plan for basin	Regulation between 2 x States and Federal Governmentt re: the basin Increased irrigated and higher productivity but less water use per hectare Basin monitoring system established for quantity and quality	20% of dry season water storage for the basin is in the upper basin using decentralised systems (farmers and cooperative owned)					

Magdalena River Basin, Colombia

	2015	2020	2025	2030	2035	2040	2045	2050
Milestone	Strengthening role of national department for consistency among sectors Joint commitments are achieved to build trust Building a process to eliminate illegal mining and mercury pollution Evaluation of research Standards, regulators better practices Clear assessments of hydropower with evidence & cost/benefit + assess alternatives Smart grid feasibility study Irrigation studies Assessment of inter-basin transfers to Orinoco: impacts on HEP, management flows and allocation, impacts on water for food Fuel substitution Concession fees spent correctly Eliminate subsides on water/tariffs reflect social realities for more efficient and rational water use	River basin and watershed planning incorporates land use planning, agriculture and environment protection National adaptation system (climate change) operational National monitoring plan in place, demand-offer-quality Strengthening of environmental institutions POT and basin management plans linked to strategic plan Small town Waste water treatment program setup Farm management to reduce nutrient /pesticide run-off Capacity and capability building, awareness raising Role of nature, improving hydro-efficiency incorporated in	Colombian water observatory is working Smart grid, agriculture co-generation, wind pilots Improve efficiencies in water use and multiple use of water upstream, downstream ecological benefits Ensure higher water use efficiencies in irrigation to meet rising demand for water in crops in cities	Institutions planning and operations use risk management for future climate change effects on agriculture/energy/water interactions All small towns have wastewater treatment with energy and nutrient recovery Portfolio operation of energy system (smart grid) to link agriculture co-generation, hydro power and wind power	Mercury contamination cleaned up Ongoing monitoring Re-investment technology upgrades			Institutional arrangement for integrated management Basin planned, orderly, consistent, operating regional environmental Council Secured permanent financial resources Flow guaranteed organic Ecosystems resilient security align and energy Protected areas declared Development of agricultural and energy that responds to the ecosystem of the basin vision Basin provides food security Efficient use of energy and nutrients by communities,
Who	Private sector Local and regional participation Institutional capacity strengthening including economics Think tank for the sustainable development of the Magdalena basin Ministry of environment, environmental authority, territorial authorities, Production Guild Smart grids, ministry of mines, energy companies, research institutes and universities Institute of Hydrology, Meteorology and Environmental Studies	Ministries, private sector, SINA, native groups and academia all involved in the planning of watersheds Investors mobilising finance into ecological restoration and the Payment of Ecosystem Services (PES)		Local,state and central governments	Navigation sector Oil producers Food producers			
Tools & Resources	National development plan Economic assessments for correct investment Cross sectorial analysis of the role of investment in forests for sustainable energy Scenario analysis, modelling Management instruments for natural resources linked with sector development policies Appropriate communication strategy for no-stakeholders Cross sectoral dialogue based on science and technical evidence Hydropower development, scenario assessments including role of nature, engineering for efficiency Knowledge environment							
Obstacles	Fragmented responsibilities, nobody takes responsibility Lack of social integration Cost barriers Insufficient technology Legal framework for energy Poor regulatory environment							
Indicators	Plan agreed: sectorial plans integrated in basin plan, under international development plan Multipurpose information system operative River basin environmental council operational		Monitoring of results from ecological restoration for energy					

Reventazón River Basin, Costa Rica

	2015	2020	2025	2030	2035	2040	2045	2050
Milestone	Analyse health components and crop type for irrigation Evaluate existing pilot project to scale up for nexus approach - the pilot project is producing biogas and reusing solids for fertilizer Can use pilot project to sell idea to municipalities Incorporate design so there is water reuse for agriculture Design WWT so can produce biogas Feasibility studies and environmental impact assessment Training incentives for biogas production Promotion to farmers on benefits of small reservoirs Feasibility study for reservoirs and dialogue with users Negotiation for land access to build micro-reservoirs Plan for food processing plant which includes a market study for food processing production Survey to measure basin council influence every 5 years	Small scale biogas in place Wastewater treatment plant in the City of Cartago Scale up of biofilters for treatment at rural level Compensation to people who lose land Processing plant for agriculture; products is in operation in the upstream part of the basin Information and capacity building for basin council Education and awareness of what is the water law and the role and responsibilities of the basin New water law to empower basin councils Private-partnership water fund Demonstrate benefits of water law - show how can be enforced and the results	Infrastructure to transport reused water for irrigation Incorporate biogas production in large WWTP Wastewater reuse for irrigation Construction of micro-reservoirs upstream High efficiency irrigation systems with reservoirs Negotiation between plant and basin authorities to make use of solid waste Update basin management plan	Turrial wastewater treatment plant constructed Updating technology for biogas production Renegotiation with farmers in mid-basin for micro-reservoirs Mid-term evaluation to improve technology Biogas and organic fertilizer produced and sold	Scaling up of micro-reservoirs in the middle of the basin Update basin management plans	Energy independent WWTPs	Update basin management plans	Wastewater treatment plants in conjunction with biofilters and wetlands for treatment; Small scale biogas production using agricultural waste; reuse of wastewater for irrigation Small reservoirs for agriculture Process foods so less dependence on exporting fresh produce Empowered basin council that is able to influence
Who	Municipality, AYA, Ministry of Environment (WWTPS) Ministry of Agriculture, Institute of Electricity (Biofilters and biogas) Energy institute, Irrigation institute Ministry of finance, Institute of irrigation, owners Ministry of agriculture, Ministry of Trade Basin commission	Municipality, basin council, AYA (WWTPs) Ministry of Agriculture, ICE, National learning institute (biofilters) Ministry of environment, Basin council Central government, National Congress, Civil Society	Irrigation institute, users, World Bank, IDB, Central American Development Bank (financing) Ministry of Environment, Energy institute, Ministry of Agriculture, AYA (Aqueduct and Sewerage Authority)	Municipality, Basin council, AYA	Municipality, Basin council, AYA			
Tools & Resources	Financial institutions, development banks Technical support and follow up Economic incentives for equipment purchase (biogas)	Training on application of biofilters Certification system for efficient agricultural production - shows water footprint and environmentally sustainable Basin councils Previous law, new law (documentation) Water balance study Basin management plan	Technical advice for design to self sustain (especially energy) Water funds Technical support from NGOs Local knowledge (facilitated by NGOs)					
Obstacles	Cultural resistance around the reuse of wastewater for irrigation and use of waste for biogas production Lack of adequate infrastructure from WWTP to irrigated areas Legal obstacles Resistance by those affected by reservoir construction Funding, political will Lack of political will Provision of good information to decision makers Change of government	Time to train and inform farmers on biofilters Lack of motivation to follow water law Law not approved/delayed	Funding Energy to pump water for irrigation Length of time to tender infrastructure Expensive technology for irrigation systems Technical expertise, financing Complex administrative					
Indicators	Feasibility study is approved with nexus view Agreement (signed) of all actors for micro-reservoirs	Agreement in place for reservoirs	Highly efficient agricultural production		Reventazon is a learning basin for the country and region	Improved water quality across the basin		

11.10 Appendix Ten - Workshop Participant Expectations

Participants were asked at the start of the workshop for their expectations. The list below includes responses received:

- Best practice experience from Latin America that will be shared around the world
- Find out how to establish a way of optimising across water, energy, food in Latin America
- Get a better understanding of the nexus challenges specific for Latin America
- Get good ideas for the integration of applications for water resources
- Get ideas for optimised solutions and existing examples
- Get solutions to the management of the water resources in Latin America
- Identify regional best practice in water, energy and food nexus
- Identify tangible actions to overcome challenges and solutions
- Identify joint work opportunities
- Learn about experiences and possible synergies in different basins of the Latin Amercia
- Learn about good practices and new methods
- Learn from and brainstorm with other participants about the role of natural infrastructure in the nexus
- Learn how to optimize
- Learn more about energy issues across South America
- Sharing with other solutions and pathways for future nexus solutions
- To get ideas on projects that can be replicated
- To get support from others on economic and technical level
- Understand current thinking in Latin America and what lessons can be learned from other places

11.11 Appendix Eleven – Workshop Participant Evaluation

Workshop participants were asked to assess the following statements as evaluation questions ranging from 1 (strongly agree) to 5 (strongly disagree):

1. The presentation on the Nexus 2050 Vision was clear and interesting.
2. The content for Latin America was informative (if not what could be improved?)
3. The Huasco River Basin case study was useful
4. It gave me a good introduction to the fictional case study (Disparate Basin)
5. The fact sheet on the Disparate River Basin was clear and concise
6. It included all information needed on problems, solutions and timeline development
7. Instructions for analysing the Disparate River Basin were clear
8. Completing the problems and solutions matrix was straightforward
9. Completing the timeline matrix was straightforward
10. Instructions for analysing real river basins were clear
11. The process of identifying solutions and developing a timeline was clear