



MARSEILLE, FRANCE '12

TIME FOR *SOLUTIONS*



# WATER, FOOD & ENERGY NEXUS

High-Level Panel of the 6<sup>th</sup> World Water Forum

TIME FOR *SOLUTIONS*



## Background to the nexus and case studies

### Background

*This publication underpins discussions of the High Level Panel on the Water, Food and Energy Nexus held during the 6th World Water Forum in Marseille on 16 March 2012.*

*It presents a collection of case studies that provide insight into the strong inter-linkages and inter-dependencies between water, food and energy at policy and project levels through the eyes and perspectives of a diverse group of organisations working across the world.*

*The Panel brings together people with the highest level of experience in the three sectors from government, the private sector, international organisations and non-governmental organisations. It aims to stimulate discussion and interaction with the audience on success stories of joined-up thinking that lead to broader benefits and provide insight into the enabling environment necessary to replicate this experience in other areas.*

*Discussion on the water, energy and food security nexus, the challenges of meeting future demands and maintaining the services provided by the environment was central to the recent Bonn2011 Conference. At its heart was a recognition that resource scarcity is not the limiting factor, but rather it is “the institutional commitment and capacity to manage scarcity by sharing resources and enabling them to be used sustainably”.*

*Sharing resources means both innovating in search of mutually beneficial solutions for water, food and energy provision, but also being able to take political decisions to adapt models of development when trade-offs are unavoidable. Key messages from Bonn2011 and background document are available at <http://www.water-energy-food.org/en/conference.html>*

*Convenors of the High Level Panel in Marseille are the EDF Group and the CGIAR Challenge Program on Water and Food (CPWF).*

### Acknowledgements

*EDF and CPWF gratefully acknowledge the significant contribution of the High Level Panel members, the members of the working group of experts tasked with preparation of the Panel and the other speakers and facilitators for their collaboration and kind participation.*

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# CASE STUDY NEXUS

## ECOWAS

Ensuring water, food and energy security  
in the ECOWAS region : a balanced policy process through  
cross analysis of long term impacts of sectoral policies  
(agriculture, energy and water)

/ AFRICA /

1. DESCRIPTION OF THE ACTORS

ECOWAS, the Economic Community of Western African States, is a regional organisation founded in 1975 gathering 15 West African states (Sénégal, Cabo Verde, Gambia, Guinea Bissau, Guinea, Liberia, Sierra Leone, Mali, Niger, Ivory Coast, Burkina Faso, Ghana, Togo, Benin, and Nigeria), and a global population of 251.646.263 people. Its mission is to promote economic integration in all fields of economic activity, particularly industry, transport, telecommunications, energy, agriculture, natural resources, commerce, monetary and financial questions, social and cultural matters.

With the overall aim of enabling economic development at the regional scale through the organisation of a common market and the interconnection of infrastructures, the Commission of ECOWAS also develops specific policy frameworks for priority sectors : it is for instance the case of an energy policy, because the lack of a stable access to energy services is recognised as the main limiting factor to economic development in the region, and because interconnection of national networks in a single power pool is believed to be central for the future; it is also the case of an agricultural policy, aiming to link all regional producers to an integrated regional market, in the general objective that this access to a regional market would be the trigger for the economic development for a very important rural population and an agricultural sector with low levels of productivity.

Because of the important proportion of water resources and basins that are transboundary (Niger, Sénégal, Volta, for instance...), the Commission of ECOWAS also has developed a specific Water Resources Coordination Centre, to ensure the coordination of regional and national sectoral policies for what concerns water resources.

The project presented here consists of a policy dialogue organised and facilitated by the Water Resources Coordination Centre of ECOWAS. The targeted stakeholders for this policy dialogue project are the different sectoral policies of ECOWAS (Directorates for Agriculture, for Energy, for Transport and also for Trade). Their strategies and sectoral policies are key drivers to reach a regionally integrated development model, which is the objective of ECOWAS, and therefore they are also key drivers of increasing and potentially competing water demands.

Member states of ECOWAS are also key stakeholders, because their domestic sectoral policies are also, often independently from one another, planning to use an increasing part of the water resources, in order to trigger development by using water as a source of energy and irrigation for agricultural development and food security.

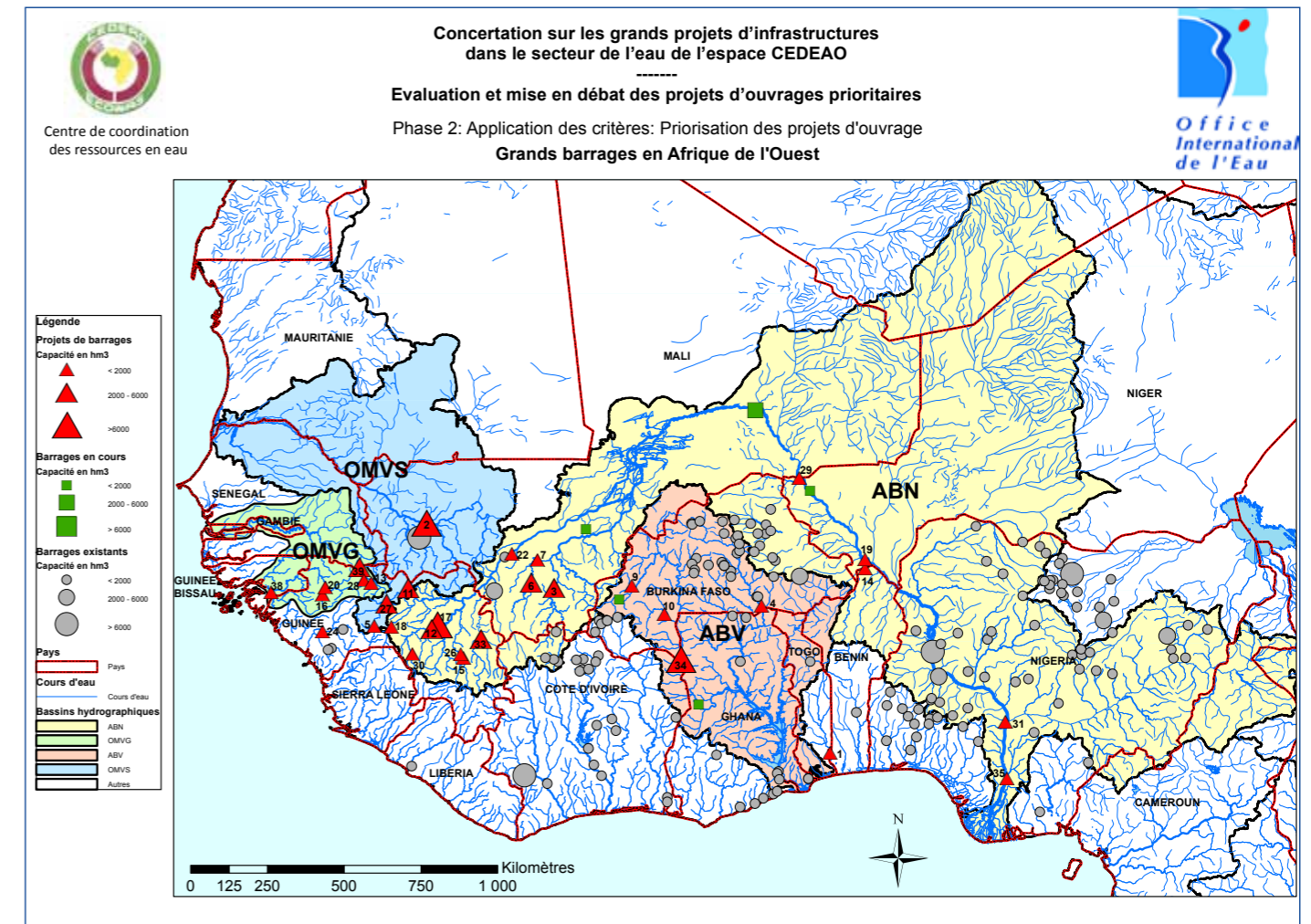
River Basin Authorities (Volta Basin Authority, Niger Basin Authority, the Organisation pour la Mise en Valeur du fleuve Sénégal, for instance) are also central institutions, because they already exist as multinational forums for water projects, but it is important to underline that some of the main drivers, like energy policies, are not decided at the scale of a basin, but at the regional or at the national scale.

2. BACKGROUND TO CASE

At the scale of ECOWAS, regional integration strategies are put in place in order to ensure integrated regional development based mainly on realising a regional common free market, a regional transport infrastructure network, and also regional policies and strategies for Energy (particularly concerning interconnection of energy networks) and for Agriculture.

At the same time, the exploitation level of water resources at the regional level has been generally considered as still very low, and it has been considered that there was room for more use of these water resources. In particular, different countries of the region were planning to implement large dam projects on shared river basins, for the priority purpose of energy production, and also, secondarily, for the irrigation of their agricultural production.

Illustration : Map of River basins and projected dams (Source : WRCU / ECOWAS)



*River basins :*  
 OMVS : Organisation de mise en valeur du Fleuve Sénégal  
 OMVG : Organisation de mise en valeur du fleuve Gambie  
 ABN : Niger Basin Authority  
 ABV : Volta Basin Authority  
*Red triangles : Projected dams (with different sizes)*  
*Green squares : Dams projects already implemented (with different sizes)*  
*Grey disks : Existing dams (with different sizes)*



### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

Although there are no conflicts on the share of water resources at the regional scale, some of the River Basin Authorities have already been useful in order to avoid conflicts in the use of shared water resources by different national states. Even if regional water resources are generally considered as “under-exploited”, the Water Resources Coordination Centre considered useful to take a prospective and precautionary approach, and to organise a policy dialogue among sectors and among countries, before the implementation of the different hydraulic infrastructure projects supported by the different countries, and before the sharp increases in water uses by different sectors linked with future economic development. The Water Resources Coordination Centre therefore launched different policy processes in order to ensure that these different development projects, programmes and strategies would be coordinated at the regional scale.

The reasons for such a coordination were the following :

- ensuring good coordination and interconnection among projected large hydraulic infrastructure,
- ensuring a policy dialogue among countries and among stakeholder groups about the downstream impacts of these projects,
- and in particular, ensuring that the aggregation of different water uses foreseen in different sectoral strategies and individual large dam projects could be balanced in order to take into account the other economic activities depending on the ecosystem services (fisheries, tourism, for instance...).

The objective was therefore to initiate a policy dialogue process on the evaluation of the cross impacts on one another of sectoral policies, decided separately from one another and at scales that are often different from the river basin scale (regional, or national). The capacity to question the sustainability of development choices resulting from potentially uncoordinated strategies, the capacity to identify a balanced development model that would not jeopardize either food security, nor energy security, nor water security, depends on the capacity to realise and discuss such cross evaluations of impacts.

### 4. LINK TO THE NEXUS

This case study particularly illustrates the necessity to focus on policy coherence in order to ensure water, food and energy security. It puts the stress on the necessity to organise policy coherence not only at the scale of water resources (here, the river basins), but also to organise policy coherence processes at the scale where economic development policies are decided (here, for instance, the regional energy policy).

Such a cross sectoral ex ante evaluation of policies does not only target water, food and agriculture, and energy policies, but also regional trade policies, that are at the heart of the economic regional integration process of ECOWAS.

Organising such a policy dialogue among sectoral policies makes it necessary to develop specific tools for the ex ante cross evaluation of sectoral plans : the scenario approach developed in this case was a first attempt at making more explicit the different types of regional development patterns and pathways that might either result from separate and uncoordinated sectoral planning processes, or that could be designed in advance thanks to the coordination of different sectors and countries.

The case study therefore also illustrates the usefulness to explicitly discuss the inter-dependency between water, food and energy security of different possible development pathways.

### 5. PROCESS, SUMMARY OF ACTION TAKEN

Two main policy processes were launched :

- a dialogue on large hydraulic infrastructures, particularly concerning multi-state projects and projects with a strong trans-boundary impact, and including a dialogue with the civil society,
- a scenario dialogue process, trying to envision different scenarios and therefore different options and models for future economic development at the regional scale, their respective projected use of water, and their impacts on the ecosystems and on the activities that are depending on these ecosystems; this scenario dialogue process was launched at the regional scale, with a specific workshop on the Volta river basin.



### 6. PLANNING AND BUDGET

Both dialogue processes were initiated by two year projects (2008-2010), composed of a series of workshops with stakeholders and policy makers, either at the regional scale, or at the scale of some river basin.

Apart from final reports, both projects were supposed to initiate permanent dialogue processes at the regional scale (the scale that is relevant concerning integrated economic development), but also specific dialogues at the scale of transnational river basins (under the umbrella of river basin authorities).

Budgetary needs were limited to the facilitation and the logistics of the workshops, as some minimum data necessary to organise scenario discussions was already gathered by different types of research projects.

### 7. PROBLEMS, DIFFICULTIES MET

From the point of view of the facilitation of the policy dialogue process, access to data was a central problem for the discussion on scenarios , but results show that important insights on development plans and their impact on the aquatic ecosystems can also be produced by a structured discussion based on existing plans and qualitative scenarios.

Another limit of this dialogue process is linked to the fact that participation to the processes was still not inclusive enough, and the participation of member states and civil society has still to be improved.

### 8. RESULTS TO DATE

The initial project for the scenario dialogue process resulted in the production of a set of scenarios at the regional scale, a strategic analysis concerning different options to reach a balanced development model at the regional scale, and the conclusions of the discussion of these scenarios at the scale of the Volta basin.

At the regional scale, the main conclusions are the following :

- irrigation projects constitute only a minor part of necessary development efforts in order to ensure rural development and food security,
- hydroelectricity might not be the only and most relevant source of energy production to trigger economic development,
- a regional development model centred on a network of interconnected multipurpose dams might be vulnerable to climate variability, which makes it necessary to further develop the sustainability analysis of this option for regional economic development,
- a regional plan for energy at a low cost is a very important option to be explored, but it might lead to a development model only centred on cities while rural population still is very important; therefore planning for rural development also remains important in order to ensure that water use for irrigation really leads to better social conditions,
- un-coordinated investments in water consuming agricultural projects and industrial/energy projects can lead to very vulnerable development pathways, because of their impacts on resources and ecosystems, and on the economic activities and poor segments of the population that are depending on the services produced by these ecosystems,
- if sectoral development strategies take into account ecosystem services, in order not to jeopardize them and in order to integrate activities based on ecosystem services in the general economic development model, such could ensure at the global level a more resilient development pathway.



## 9. LESSONS LEARNT

Apart from the conclusions at regional and basin scale, the conclusion of the initial project of scenario dialogue process is that :

- River basin scale policy dialogues on water have to be complemented with water-centred dialogues at scales relevant for economic development (here, the regional scale) : this second type of policy dialogue has to be developed, as they are not very usual for the moment. It is also at these scales (regional, national), that the water/food/energy nexus has to be the object of policy making, particularly when it comes to integrated regional trade policies.
- Long term impacts on water and ecosystems of individual or sectoral projects and strategies have to be anticipated in order to ensure sustainable and resilient development pathways,
- A permanent dialogue process among stakeholders responsible for long term strategies and planning of different water uses is necessary to ensure a balanced development model, and is therefore an important component of policy processes for sustainable development.

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Approval of Ecowas WRCC

Website : <http://www.wrcu.ecowas.int/fr/homefr.htm>



# CASE STUDY CASE STUDY NEXUS

WATER FOR FOOD,  
ENERGY AND ECOSYSTEMS :  
Case of the Inner Niger Delta, Mali

/ AFRICA /



## 1. DESCRIPTION OF THE ACTORS

**A) Actors at the Niger Basin Level :** Niger Basin Authority (NBA): The Niger Basin Authority defines its purpose as the promotion of cooperation among member countries to ensure integrated development of resources. While focusing on the management of water and hydroelectric resources, the NBA nations (Guinea, Mali, Niger, Chad, Burkina Faso, Ivory Coast, Nigeria, Benin, Cameroon) use the organization to harmonise development of energy, agriculture, forestry, transport, communications, and industrial resources of the member nations. The Member States of the Niger Basin Authority adopted the Niger Basin Water Charter that came into force in July 19, 2010 which is formally dedicated to address the fundamental right of access to water.

**B) Actors at the Mali Government and the Upper Niger Levels :** The Government of Mali: is mobilizing water resources through many dam buildings on the Niger River to promote food security and energy production. Energy du Mali (EDM). is a private electricity company, providing electricity to many cities in Mali including Bamako, through Selingue (46,2 MW of installed capacity and 247,4 GWh about 28,0 % of national production ), Sotuba dam (5,7 MW of installed capacity and 34,5 GWh, about 3,9 % of national production). Office du Niger: manages the irrigation zone enabled by the Markala dam supporting 52% of the national rice production. It takes 2.69 km<sup>3</sup> from the Niger River annually. The plan is for the total irrigated zone to extend to 193 394 ha in 2013-2020.

Talo dam: built in 2005 in the Bani River. The plan is to develop 20,320 ha, of which 16,030 irrigated rice fields; the rest is planned to be converted into bourgou (water meadows) and fish ponds. The reservoir would remain small (maximum surface 50 km<sup>2</sup>, maximum volume 0.18 km<sup>3</sup>)

Fomi dam (Guinea): The Authority of Fomi dam is responsible. Construction is planned in the Niandan tributary in Guinea-Conakry. The expected potential annual electricity production will vary between 136 GWh in a dry year and 357 GWh in a wet year and amounts to 243 GWh, on average.

Other Offices for rice production using different irrigation schemes (sluices) according to the flooding levels of the Niger River: Office Riz Segou, Office Riz Mopti, Office Developpement Rural Selingue

National Directorate of Hydrology: Its mission is the development of elements of the national policy on water supply, coordination and technical supervision of regional services, sub-regional and related services that contribute to implementing that policy. Recently it an inter-ministerial commission for managing of water resources of the Upper Niger was established, mainly dealing with the Selingue and Markala dams.

**C) Actors at the Inner Niger Delta Level (IND): Farmers, herders and fishers:** A million and half people fully depend on exploitation of the natural resources of the Inner Niger Delta as rice farmers (5000 -170 000 t floating rice/year), cattle breeders (2 million cattle and 5 millions of small ruminants and fishers (50 -100 000 t/fish/ year). The flooding is the engine of the socio-economic development and ecology integrity.

**D) International communities.** The IND is Ramsar site and is a hotspot of biodiversity for 117 waterbird species, some large mammals (hippopotamus and manatee). 3-4 million waterbirds use the zone as a wintering area. The global population trends of many waterbird populations are highly correlated with the ecology integrity of the delta wetland habitats (including the river, lakes, flooded forests, Echinochloa stagnina fields, etc.)

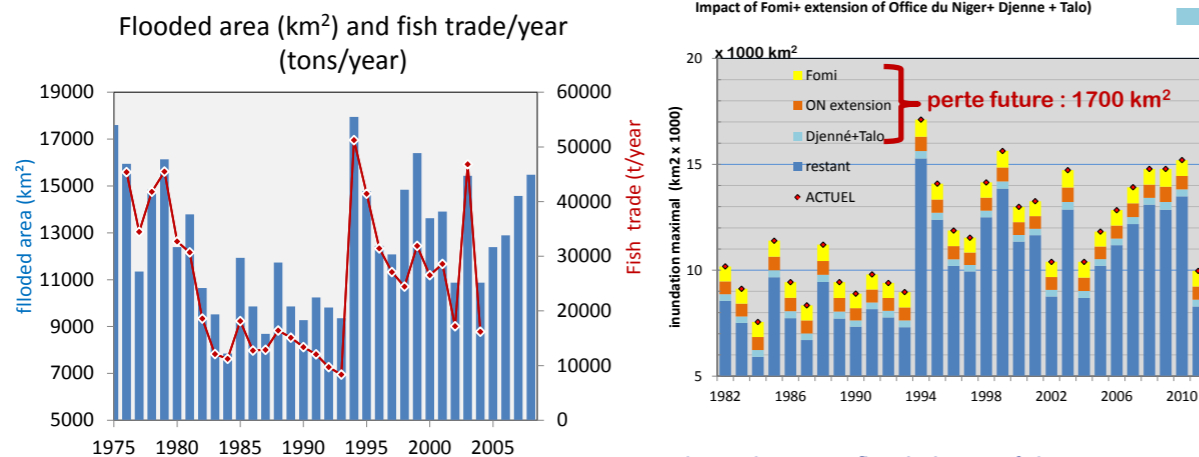
## 2. BACKGROUND TO CASE

The promotion of food security is the top priority of the Malian Government. It results in a push for more irrigated areas demanding that more water is extracted from the Niger River and at the same time water is needed for the booming energy production. Water, however, is scarce and crucial to other sectors, not least for the flood-driven ecosystem, food security and economy of the downstream Inner Niger Delta communities. In years of low floods, extreme humanitarian disasters occur.

The increased diversion of water upstream has also been shown to accentuate human health and sanitation problems in the region. Due to this increasing competition for water and the direct and indirect impacts of changing the water regimes, there is an urgent need to consider the trade-offs of different water management scenarios including the impacts for all stakeholders in a catchment context.

### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

**Reasons for Action :** Three-quarters of the population of the IND live below the national poverty line. The large water infrastructures upstream have led to a transfer of welfare from downstream to upstream while contributing to national food security and electricity production. The flooding of the IND is the engine for socio-economic development, ecological integrity and community resilience. However, climate change (rainfall and temperature) and dam diversions have drastically reduced the seasonal dynamics of the river and the flooded area of the IND by 6 000 km<sup>2</sup> (1923-2005) and 2760 km<sup>2</sup> (Selingue dam 650 km<sup>2</sup>, Office du Niger, 370 km<sup>2</sup>, Fomi 740 km<sup>2</sup>, Extension of Office du Niger 630 km<sup>2</sup>, Djenne + Talo 370 km<sup>2</sup>). The planned extension of Office du Niger + Talo + Djenne + Fomi which represents 1700 km<sup>2</sup> is placing community livelihoods under increasing risk. The catastrophic drought years are becoming more frequent, leading to “young local communities of the IND voting with their feet” and leaving more vulnerable groups (children, old people and women) at high risk.



Relation between flooded area of the IND and the fish trade at Mopti

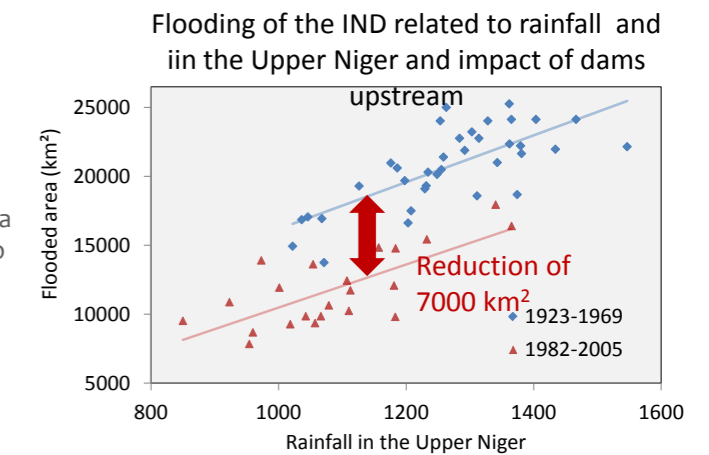
**Proposed solutions** (based on analyses and conclusions from a number of projects carried out with partners, reported on in “Niger, a lifeline “ (Zwarts et al. 2005) ; Water Sharing in the Upper Niger Basin (Altenburg & Wymenga report 1739, 2012)

**Stakeholder engagement and coordination for IWRM :** Currently IWRM is practised on only a local scale. There needs to be a civil society platform and improved information flow amongst stakeholders, across scales and sectors to enable coordination upstream-downstream in the Upper Niger Basin.

**Water sharing :** The development and use of a policy for allocation of sufficient water (flood duration and depth) for the delta to sustain food production and ecosystems, would provide a long-term guarantee for delta communities and avoid that this water is diverted upstream for highly water consumptive cash crops in irrigated areas such as cotton and biofuels. Optimising water sharing will require international cooperation and improved water governance at the whole basin level, linked to a thorough trade-off analysis.

**Decision-support models operational :** The hydrology, ecology and economy of the Upper Niger and IND have been studied for decades. This knowledge base, including a flooding model, makes it possible to quantify the downstream impact on river discharge and food production of upstream interventions. A decision support model (DECIDAID) was built based on this, to facilitate IWRM. This provides the basis to identify the best approaches, to integrate food security, land and water use, and other sectors. However, DECIDAID is not yet operational. Additionally, scaling up and mainstreaming the OPIDIN flood prediction model and tool that informs adaptation options for local communities, would result in increased community resilience to low and high floods.

**Improved water efficiency :** The Partners for Water project which resulted in “Niger, a lifeline “ (Zwarts et al. 2005) showed, that investing in existing infrastructures and a more efficient water use would be more effective, in terms of economic gains, than building new infrastructures. There is considerable room for water savings and increased productivity per cubic metre of water through improving water efficiency in the irrigated zones, especially in the dry months. Additionally, selection of less consumptive crops (e.g. vegetables instead of sugar cane) and rice varieties would provide water saving benefits.



**Alternatives to hydropower :** The current and planned hydropower in Mali will not be able to meet the fast growing demand. Additionally, the unpredictability of rainfall in the Sahel works against stable production of electricity. Small scale pilots suggest that solar power is a promising alternative for Mali, which has on average 300 sunny days per year.

#### Scale up and mainstreaming of pilot solutions :

In the Inner Niger Delta several successful pilots have been carried out on ‘green developments’ or development measures which support the ecosystem functioning. These include forest regeneration and fish pond restoration. There are opportunities also to improve the design of irrigation schemes to enable ecological functioning and habitat creation.

**Sustainable use of natural resources :** Safeguarding and maintaining the natural assets of the delta (such as fish stocks, flood forests, bourgou fields) depends on the maintenance of the flood regime but additionally the prevention of over-exploitation and habitat degradation. Pilot initiatives have demonstrated that over-exploitation can be averted through providing incentives and access to promising economic alternatives, as well as by law enforcement.

### 4. LINK TO THE NEXUS

In Mali, the limited water resources of the Niger and Bani rivers play a pivotal role in economic development for rural and urban communities. The large annual variation in the river flows is reflected in the production of food with more famine years occurring during the last decades. The predominant institutional response to this climatic uncertainty has been the development of hydroelectric and irrigation schemes, aiming to reduce economic dependence and increase national food security. As a result, the competition for water resources between the agricultural and energy sector has intensified and ecosystem services have been degraded or lost, resulting in reduced food security downstream in the IND. It has therefore become important to clarify the trade-offs and inter-linkages between different sectoral objectives and their seasonal water demands.

Table 1: Competition between sectors for water resources for food and electricity production and biodiversity

Niger River and its tributaries (Sankarani +Bani)			
Upstream (Upper Niger)		Downstream (Inner Niger Delta)	
Impact of Water management upstream on food and electricity production		Ecosystem services provided by natural flow	Impact of water management upstream (ecosystems services lost in the IND)
Rice production(t)	700 000 (52% of national Rice consumption)	25000- 170 000 (30% of the national rice consumption)	-40%
Fish production (t)	4 000 (5%)	50 000- 100 000 (80% of national fish production)	-37%
Electricity production (GWh)	640 (32% without Fomi dam)	-	-
Livestock (number of cattle and small ruminants respectively)	1 200 000 and 2 000 000	2 000 000 and 5 000 000	-15 and -4%
Biodiversity (waterbirds)	2 700 – 3 000	3- 4 000 000	High rate of mortality





### 5. PROCESS, SUMMARY OF ACTION TAKEN

- Documentation of the best scientific knowledge about the competition between food, electricity production and biodiversity and translation of this information into understandable materials for different target groups (Ministries, National Assembly, Niger Basin Authority, local and regional decision makers, rice farmers, herders and fishers)
- Participation in many national, regional and international fora presenting the case of the Inner Niger Delta and distribution of thousands of brochures translated into local languages summarizing the current situation
- Technical and policy support to the Government of Mali for the development of “Sustainable Development Program of the Inner Niger Delta”
- Sensitize the Government of Mali for an urgent need to establish a multi-actors committee under the Supervision of the Prime Minister for integrated management of the Upper Niger and Inner Niger water resources.
- Development of a National Action Plan for Integrated Water Resources Management
- Lobbying and policy advocacy to riparian country governments, the Niger Basin Authority, bilateral and multilateral donors pressing for revision of their policies on dam construction.

### 6. PROBLEMS, DIFFICULTIES MET

- The Government of Mali aims to extend Office du Niger irrigated area by more 1 million ha and the water resources for this irrigation is not available
- Many national and foreign investors have bought lands at Office du Niger at the expense of local rice farmers
- Political tensions – there are negative reactions from the delegates of the Republic of Guinea at the regional and international meetings when showing the impact scenario of Fomi dam in the Inner Niger Delta
- The existence of many policies and institutions in Mali related to the water sector have led to the sectoral management of water resources
- The lack of lobbying groups for the IND, whose interests need defending at the highest political level

### 7. RESULTS TO DATE AND FUTURE COMMITMENTS

- Scientific knowledge available (models and tools ) which could support and inform the integrated management of water resources of the Upper Niger and Inner Niger Delta
- Existence of a Sustainable Development Programme for the Inner Niger Delta
- The IND is the focus of many bilateral and multilateral donors
- The Government of Mali is willing to extend the terms of Reference (decision about the sharing of water resources between electricity, agriculture and ecological flow) of the water resource management commission of the Selingue dam to the Markala dam and the Inner Niger Delta

### 8. LESSONS LEARNT

- Availability of data and sound scientific knowledge about the competition between food production, energy and ecosystems in the Upper Niger and the Inner Niger Delta is a valuable tool for raising awareness amongst policy makers and users of water resources
- Confidence and trust has been established between our institution, the Malian Government and bilateral donors about the value of our work resulting in Wetlands International becoming a key player in the development of the Sustainable Development Plan for the IND
- Development of Niger River basin and/or sub-basin water resource management tools for use by decision makers and local stakeholders is an important step to improve the capacity of the future water governance body (which will establish during the implementation of the Sustainable Development Program of the IND for decision taking
- The sectoral approach currently applied to management of the water resources of the Upper Niger and IND has led to more conflicts between sectors and water users.

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case 3



# CASE STUDY NEXUS

CONSEJO DE LA CUENCA  
DEL RIO MACHANGARA  
CCRM / Machangara River Basin  
Council

/ SOUTH AMERICA /



## 1.. DESCRIPTION OF THE ACTORS

The actors listed below belong to the Machángara River Basin Council:

- **ETAPA** is the municipal public telecommunications, potable water, sewer and sanitation service company of the city of Cuenca: It uses the waters of the Machángara River, which currently supplies 800 liters per second, in order to provide potable water and sewer service to 40% of the population concentrated in the city of Cuenca (505,500 inhabitants), the city with the third largest population in Ecuador.
- **ELECAUSTRO S.A.**, Empresa Electro Generadora del Austro (Electricity Generation Company of the Austro), has two hydroelectric power plants in the basin. The SAUCAY power plant uses 9,000 liters of water per second, and the SAYMIRIN plant uses 7,200 liters per second. All of this energy contributes to Ecuador's national hydroelectric production. In addition, ELECAUSTRO has two regulating dams with a storage volume of 23 million cubic meters of water.
- **The JGUSRM**, Junta General de Usuarios del Sistema de Riego Machángara (Machángara Water Users Board), is composed of the users pertaining to the Machángara and Checa – Sidcay irrigation sectors. The Machángara irrigation channel has a capacity of 770 liters per second and provides water for the irrigation of 584 hectares, benefiting 2,325 families, while the Checa – Sidcay irrigation channel has a capacity of 700 liters per second and supplies water to irrigate 800 hectares, benefiting 800 users. Among the main crops are vegetables, grasses, tubers and grains.
- **Small-scale farmers in the middle and upper parts of the basin** grow corn, beans, oats, wheat, barley and peas, and have small fruit orchards as well. Their agricultural production is basically for home use, although small surpluses are sold in local markets. Livestock raising is a very important activity, since they take advantage of the large moors for pasturing their animals, which are mainly cattle for a twofold purpose: production of meat and milk.
- **The industrial park** located in the lower part of the basin is composed of 120 companies in diverse industries that invigorate the local and national economy.
- **The Secretaria Nacional del Agua (SENAGUA / National Secretariat for Water)** is the supervisory institution for water resources in Ecuador, whose mission is to oversee integral integrated water management throughout the national territory, through policies, regulations, monitoring and decentralized management.
- **The Instituto Nacional del Riego (INAR / National Irrigation Institute)** is the entity that heads integral irrigation and drainage management nationwide, with the objective of “Consolidating and executing the National Irrigation and Drainage Plan through the establishment of public policies that contribute to agricultural development in order to guarantee food sovereignty”.
- **The provincial government of Azuay** is the local government that promotes and executes works at the provincial level, with regard to the environment, irrigation and management of the river basins and microbasins under its jurisdiction, among other matters.
- **Universidad de Cuenca** is the oldest institution of higher education in the Austro area of southern Ecuador, whose objective is to contribute to the country's development by shaping professionals and providing extension and research activities.
- **The Ministry of Environment**, the entity responsible for enforcing environmental legislation with regard to the conservation of flora, fauna and wildlife, became part of the Council in September 2001.

## 2.BACKGROUND TO CASE

The Andean region is one of the planet's most diverse regions due its great natural and cultural wealth. It contains approximately 25% of the world's biodiversity in 7 ecological strata and 133 different ecosystems (SGCAN 2009), with precipitation ranging from 30 to 9,000 mm/year and temperatures that vary from -10 to 40°C (SGCAN 2010). The hydrological characteristics of the Andean basins are also highly diverse; depending on their location with regard to the mountain range, their flows may be relatively homogenous (Atlantic slope) or highly variable (Pacific slope). At the same time, the Andean mountain range, which is the backbone of the region, has an enormous number of basins with particular sizes and characteristics.



The Andes has an enormous altitudinal gradient from sea level to 6,746 masl, where topographical conditions have potential for hydroelectric power generation in all of the region's basins (SGCAN 2010): Ecuador's is estimated at 21,520 MW (CONELEC 2009); Peru's is estimated at 58,937 MW (GTZ & LIS, 1979) and Bolivia has a potential of 39,870 MW, but only takes advantage of 1.2% (ENDE 1987).

The development of the Andean population depends on water and its hydrological environmental services. It is estimated that these environmental services benefit more than 100 million people (IUCN, 2002), primarily by providing and regulating water for urban use, agriculture and the generation of hydroelectric power (Buytaert et al 2006). On average, in countries in the Andean Community (Colombia, Ecuador, Peru and Bolivia), 78% of the water is used for agriculture, 13% for domestic use and 9% for industrial use. There is great potential for saving water and increasing efficiency in its use, since currently the efficiency level in the use of water for irrigation is only 35%, and 60% in the case of domestic water consumption (SGCAN 2010).

The issue of water management in river basins is gaining momentum in the Andes. Laws have been approved in Venezuela and Peru; Argentina and Colombia have special laws and, in Ecuador and Bolivia, proposed laws are still being debated (Dourojeanni 2010). Although the management of river basins has been discussed for nearly 40 years, little real progress has been made in practice. Only in a limited number of cases have solid systems been established for governance among multiple water users (Dourojeanni A. 2011). The Machángara River basin is highly representative of Andean basins because it is a basin with multiple uses on which hundreds of thousands of users depend. This dependence results in increasing pressure on ecosystems, which has caused constant degradation, fueled by population growth, increased extractive activities and the intensification of natural disasters associated with climate change.

The basin is located in the Inter-Andean region of southern Ecuador (Figure 1), in the provinces of Azuay and Cañar, with a total surface area of 235 km<sup>2</sup>. It is a sub-basin of the Paute River which belongs to the Santiago hydrographic system on the Atlantic slope, and is considered one of the country's most important, since it is the location of two hydroelectric power plants which are single purpose and provides water for the city of Cuenca. In addition, 77% of the total surface of the basin belongs to the Machangara-Tomebamba Protected Forest. According to the Ministry of Environment, this space collects approximately 305 cubic hectares of rainwater every year, as a result of having 1118.40 mm/year average annual precipitation (IHHA, 2006).



Figure 1: Location of the Machángara River basin

## 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

Prior to the formation of the Machángara River Basin Council in 1998, the basin was a space for the exploitation of resources, where a sectorized perspective and use of water prevailed. The electricity sector, the public potable water and sewer service sector and the irrigation sector used the water destined for the different uses as they saw fit, with little coordination among them, which turned into a competition and a source of conflict.

Thirty-two conflicts have been recorded typically between hydropower companies and upstream communities and downstream irrigation users, with access to water as the main cause of conflicts and tension among the different users. Other causes are pollution of water sources by the mining industry, inadequate management of solid waste and wastewater, and private appropriation of land in the upper part of the basin, especially the moors.

Water management in the basin was markedly sectorial. There are 11 public entities with water management authority in the province, with overlapping roles and functions, and there were no clear coordination mechanisms or joint actions. Land use was disorderly, with a weak system for control over aspects associated with the location of public works, mining operations, aggregate extraction, fish farming, agriculture, urbanization and industrial operations.



The basin had vulnerable areas due to geological conditions, as well as improper use of natural resources, including an increase in deforestation and crops on high slopes, which caused water pollution and the accumulation of sediments in water regulating works used as sources to supply electrical and potable water systems. In the upper basin, extensive pasturing of cattle and horses prevailed, which added to soil degradation and water pollution. In addition, there was the seasonal burning of vegetation from grasslands to obtain straw used as cattle feed. An on-going threat was the logging of native trees and the collection of brush to be used as fuel by families living in the basin or to generate income from selling it.

Analysis of the problem determined that the impact on the rural population was significant, as their productive capacity and basic means of subsistence were endangered as a consequence of the degradation of soils and the vegetation cover, establishing the need for conservation activities in this part of the basin. In addition, it revealed the need to implement negotiation processes and to reach agreements among the different users in order to improve the efficiency of water use and guarantee its supply in a context of population growth and climate change.

Objectives: In this context, the Basin Council established the objective of achieving effective coordination among the participating institutions and users in the basin to make its sustainable development possible, with emphasis on water management as part of natural resource management. For this purpose, the need to foster and implement integral management of water resources in the jurisdiction of the Machángara basin was identified, using the policies established by the SENAGUA as a basis. In addition, a formal basis for future inter-institutional relations was created in order to unify initiatives and avoid duplication of efforts in the technical, administrative, economic and logistical areas related to the project, as well as to take advantage of the resources available to institutions in their field of competence in order to facilitate technical cooperation.

#### 4. LINK TO THE NEXUS

For the purpose of dealing with the aforementioned problems, on July 28, 1998 an inter-institutional agreement was signed on the formation of the Basin Council for integral management of the Machángara River basin. This council has a board of directors, a technical committee and a technical secretariat in charge of supervising and coordinating the council's actions with its members and other organizations that are not participants in the council. The objective is to facilitate consensus on the exploitation of water and other natural resources and uses of water, from a sustainable perspective, manage resources and applicable legislation based on participatory proposals in local, national and international contexts, plan sustainable development of the basin and stimulate actions and initiatives of actors that contribute to conservation of the basin.

Machangara River Basin is one of 10 selected watersheds in the study on successful experiences of integrated water management of catchments in the Andean region that was carried out by the CGIAR Challenge Program on Water and Food (CPWF) and CONDESAN in the Andes Research Program.

#### 5. PROCESS, SUMMARY OF ACTION TAKEN

In the year 2001, a strategic plan was formulated, establishing a vision of forming a leading hydrographic basin network with clear environmental sensitivity, generating a water culture among the inhabitants of the region. For this purpose, a process was implemented to coordinate and articulate the capacities and resources of member organizations and institutions for management of the basin. In this process, some important milestones have been identified: In 2003, the main organizations that exchange experiences, information, technology and financial and legal mechanisms implemented as part of the management of the basin were integrated. In 2005, actions were established in the framework of the territorial planning and management plan and, in 2007, a plan was implemented for the exploitation of natural resources, particularly follow-up, evaluation, monitoring and oversight regarding water.

The following are among the main strategies implemented :

- Continuous inter-institutional coordination, primarily among municipalities, rural communities and the Ministry of Environment, resulting in the signing of agreements
- Technical assistance and extension programs with the support of certified communal promoters, community management of natural resources, Guardianía Verde (green guardians), and environmental education



- Communication and dissemination process, by first making an impact on individual knowledge and subsequently, on shared knowledge
- Empowerment of the middle levels of participating organizations for sustainability of the process, avoiding stagnation due to changes at managerial levels
- Articulation of the basin management process with governmental processes such as forest partners, moor partners and FONAGUA
- Implementation of political dialogue to analyze problems and determine solutions and commitments among the participants
- Experience as a training space and this as a strategy for learning and feedback on the process

#### 6. PLANNING AND BUDGET

The Machangara Basin Council implements its activities under the Development Plan prepared every 10 years, which identifies priority actions for the basin during that period.

The plan is financed primarily by ETAPA and ElecAustro, and also by some government projects and international cooperation. The ETAPA funds come from the potable water service that charges 0.05 USD/m<sup>3</sup> of drinking water. The ElecAustro funds come from their environment program.

The Basin Council had a budget of 130,000 USD in its first phase (2003 - 2006). In the second phase (2007 - 2010) the fund grew to 715,000 USD, and the budget is expected to continue to grow in coming years.

#### 7. PROBLEMS, DIFFICULTIES MET

- Ecuadorian legislation does not legally recognize the Basin Council as an organization, which results in a legal vacuum that keeps it from obtaining legal person status in order to act independently without depending on the intermediation or representation by its member organizations. Despite this limitation, the Basin Council is progressing and obtaining good results. So far, it has operated under a circle-of-friends format that enables it to adapt to rapidly changing conditions.
- 46% of the population of Cuenca does not know where its potable water comes from and is unaware of the regulating hydrological service that the basin provides or its importance; greater creativity and effort are needed to raise awareness among the population.
- In the spirit of cooperation, the technical secretariat of the Basin Council has been operating in the offices of ETAPA. This has led to confusion among the population, which identifies the Basin Council as an ETAPA project. The Basin Council needs to have a permanent technical team with its own office space.

#### 8. RESULTS TO DATE

- Institutional participation, consensus building, coordination and COMPETENCE-based work: City Hall is responsible for urban planning and legal compliance; the university for research and technical extension work; ETAPA, ELECAUSTRO and JGUSRM for financing the process in different ways and according to their possibilities; and the Ministry of Environment for regulation and legal compliance. This is achieved based on negotiation with reliable information that makes it possible to understand that in the basin there are a number of water users and they all have the same rights and obligations.
- The formation of the water fund for the Machángara River basin, whose largest contributors are ETAPA, ELECAUSTRO and JGUSRM. This fund is the basis that enables the council to carry out its conservation actions in the basin in order to ensure continuous provision of hydrological environmental services.
- Guardianía Verde (green guardians) program through the inter-institutional cooperation agreement between ELECAUSTRO and ETAPA, whose objective is "to avoid changes in soil use in the area of the Machángara – Tomebamba Protected Forest".
- The Community Natural Resource Management Program, whose purpose is to improve the quality of life of the rural families living in the middle and lower parts of the basin as a strategy to avoid the expansion of agricultural



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areas to the upper parts of the water-producing basin. This strategy, called “protection of the source outside the source”, involves 1,400 families who have successfully implemented agroforestry practices and conservation of resources.

- Development of talent through the meeting of knowledge between the technical world and local capacities, achieving the training of community promoters, who provide their services in the basin, in the “School of Continuing Knowledge on Community Management of Natural Resources, Leadership and Management” program and certification from Universidad de Cuenca.
- Under the concept of “a trained child is one less adult to be trained”, ETAPA promotes the “Agua Vida” Rural Environmental Education Program which to date has trained more than 1050 children on environmental protection with a hydrographic-basin approach. In addition, ELECAUSTRO has trained 1070 school children in its environmental education program called “Significant learning for the prevention of negative environmental impacts”.
- Political dialogues with the participation of the chairpersons of the parish boards, environmental delegates, political lieutenants, chairpersons of water boards and committees, and delegates of the institutions composing the Basin Council.
- Environmental awareness-raising as a communication and dissemination policy. With support from Universidad de Cuenca, CREA and ELECAUSTRO have created a council website: [www.consejodelmachangara.com.ec](http://www.consejodelmachangara.com.ec).
- The Machángara basin is a reference source on the management and conservation of natural resources with institutional community participation. For this reason, it has been turned into a training space for different groups, such as students from schools and universities in different Peruvian cities.
- Research and promotion through an agreement on conservation of the basin signed by ETAPA and ELECAUSTRO. The physiochemical and bacteriological condition of the water at strategic points of interest to both companies is monitored quarterly. This has led to identification of the self-purifying power of the Machángara River with regard to organic sources of pollution.
- Considering the purchase of properties as a fundamental strategy for conservation of the upper Machángara basin, ETAPA acquired 1410 hectares that compose the Chanlud Protected Area.

## 9. LESSONS LEARNT

- When a company adopts the basin approach to resource management, it is recognized as another development actor and is capable of approaching other actors in its context and even leading dialogue and consensus building for sustainable resource management, reducing the level of social conflict, improving the availability and quality of the resource it uses and increasing its profitability.
- The Basin Council as a management platform makes it possible to optimize the technical, economic and human resources of the entities or organizations involved, due to which the investments required to manage a basin are shared. In addition, duplicating functions is avoided and organizational strengthening and exchange between participating organizations are promoted.
- An established national and/or local legal framework is not necessarily required in order to form a basin council. In its absence, the formation of a basin council could provide the inputs for the construction of effective legal and inter-institutional frameworks.
- The formation of a basin council through the implementation of its different tools not only contributes to integral resource management; it also generates sources of employment and higher income for the local population.
- The generation of reliable local information and access to it, communicated through adequate systems, enables the actors in the basin to understand the socio-environmental processes in which they are involved, facilitating dialogue and better decision making.



#### Factors of success :

- Work at the managerial and technical level in order to achieve institutional participation in the process, with strategies such as lobbying among managers and mid-level employees, as well as individual and shared convictions
- As institutions forming the Basin Council have financing capacity and are users of the basin, coordinated actions are taken based on common interests and objectives.
- Signing of inter-institutional coordination agreements on conservation with local governments, communities and other actors according to the competences of each institution. They recognize and share the benefits of coordinated efforts, which motivates them to continue contributing.
- Concrete actions in the field, some of which articulate conservation with productive projects in order to gain credibility and trust among members of the council and the population of the basin
- It is a basin that is regulated by the Chanlud dam (17 hectometers) and the El Labrado dam (6 hectometers), which permits planning use of the resource.
- Strategy for communication and large amount of information on the basin, drawn up by institutions.
- Committed promoters with real authority granted by the Ministry of Environment and certification from Universidad de Cuenca
- Effective control system composed of forest rangers and communal promoters as guards, and CCRM with the capacity to exert pressure and facilitate the Ministry of Environment's efforts to enforce legal sanctions

#### Possibilities for replication :

- The Machángara River basin is representative of the Andes, where the main water users are cities, agriculture and hydroelectric power plants.
- The experience of the Machángara River Basin Council has been obtained based on its will to coordinate and agree upon the best way to manage water and other natural resources, despite not having legal recognition of the Basin Council as such, demonstrating that efficient water management is achieved based on the actors willingness to engage in dialogue based on reliable information.
- The legislation on water management in several countries in the region has recently incorporated the basin approach. All of them consider the formation of basin councils, due to which methodologies and tools are being established for their formation. This experience could be the basis for promoting and consolidating these platforms.
- In the region there are several basins with conflicts among users of water for irrigation and hydroelectricity generation companies. The causes vary, but all of them have to do with access to water, adequate management of flows and the impacts of the construction of storage dams. Machángara has developed different negotiation mechanisms that have made it possible to reach agreements on harmonious use of water in the basin.
- The Machángara experience has developed and implemented several mechanisms for sharing the benefits of the basin's water, among which the following stand out: the water fund, green guardian programs, and the program for community management of natural resources, among others. This demonstrates that mechanisms for sharing benefits are an important tool for managing the basin.

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# CASE STUDY NEXUS

Improving the water and energy  
efficiency for food production  
through drip irrigation in India

/ INDIA /



### 1. STAKEHOLDERS

Agriculture and water management in India is a multi-dimensional issue and hence requires multi-pronged approach. Jain Irrigation Systems Limited (JISL) shows a successful case of integrated agriculture management through stakeholders' participation. It involved experimenting on their own, pulling knowledge from academia and research institutes, demonstrating benefits of micro-irrigation technologies to farmers and farmers' associations, bringing financial institutions with finance and advocating with government for the right policy framework. JISL also join hands with the corporate sector for sustainable supply chain management. JISL have two on-site R&D farms in Jalgaon, Maharashtra and Udumalpet, Tamil Nadu, India. This is a case of astute work to spread the drip irrigation technology even to small holding farmer in India.

Key stakeholders are :

- a. Farmers – small to large
- b. Cooperatives and private sugar factories
- c. International institutes like ICRISAT, IRRI
- d. Agricultural universities, India and abroad
- e. Banks and financial institutes
- f. Governments (central and states in India)
- g. Corporate sectors (e.g. Unilevel, Coca cola)

### 2. BACKGROUND

India is the largest freshwater user in the world, and the country's total water use is greater than any other continent. The agricultural sector is the biggest user of water, followed by the domestic sector and the industrial sector. Groundwater contributes to around 65% of the country's total water demand, and plays an important role in shaping the nation's economic and social development.

On the other hand, feeding country's own population, which is 17% of the world with just 4% of world's water resources at hand, is a big challenge. Balancing water demand among all sectors with finite and fragile water resources will be crucial for future economic growth and development.

As water demand from cities and industries is increasing rapidly, pressure is also mounting on agriculture to enhance water efficiency. Traditional irrigation methods are no longer viable and a paradigm shift is required to increase irrigation efficiency. With around two third of Indians depend upon agrarian economy, water is becoming a bottleneck for country's socio-economic balance and growth.

As water demand management measure in agriculture, recently micro-irrigation technologies, which mainly includes drip and sprinkler irrigation methods have been introduced. Unlike conventional flood irrigation, water in this method is supplied at a required interval and quantity using piped network, emitters and nozzles. Thus, the conveyance and distribution losses are reduced which results into higher water use efficiency. Minimising water use also reduces energy use for pumping groundwater. Thus, micro-irrigation technologies co-optimize both energy and water use.

### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

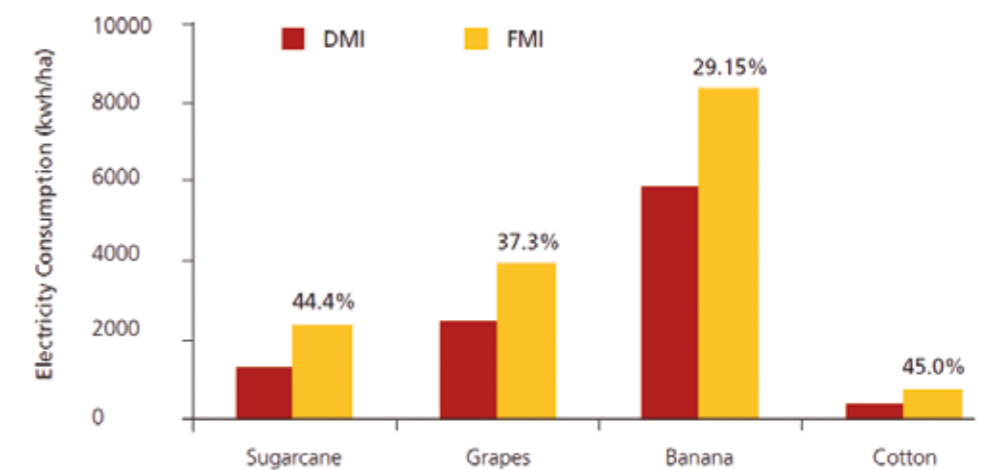
Conventional irrigation methods are employed for more than 80 per cent of the world's irrigated lands yet their field level application efficiency is only 40-50 per cent. In contrast, drip irrigation has field level application efficiencies of 70-90 per cent as surface runoff and deep percolation losses are minimized. All agricultural operations require energy in the form of electricity, the magnitude of which varies as per different agro-climatic zones and even from farmer to farmer. The largest share of energy is utilized for pumping of irrigation water. Various research studies have shown that water saving, electricity saving, irrigation efficiencies and yield of crops using drip irrigation are substantially higher than crops irrigated by the conventional flood irrigation method.

The modern irrigation systems, drip and sprinkler can act as a mitigation measure over this problem. Eventually with little water available in Indian subcontinent, crop can survive and we can virtually come out the over dependency on monsoon. Because, whatever rain is available in arid regions can be will be stored and water applied to root zone with drip, will bring this region out 'rain feed' clutches with increased productivity.

- Drip irrigation saves water up to 30% to 70% for various crops
- Saving of water saves electricity which is used for pumping ground water.
- Drip irrigation also improves the yield of the 30% to 200% for various crops.
- This assures good technology transfer and knowledge tool in the hands of illiterate farmers.

The water savings due to widely spaced crop is 300 mm/year and closely spaced crop is 500 mm/year (National Mission on Micro Irrigation, 2003). This water savings is directly proportional to energy savings (Narayanmurty, 2007).

Some facts above energy savings due to drip irrigation (Narayanmurty, 2007)



Demonstration at JAIN'S R&D farm, drip irrigated cotton with solar powered pump





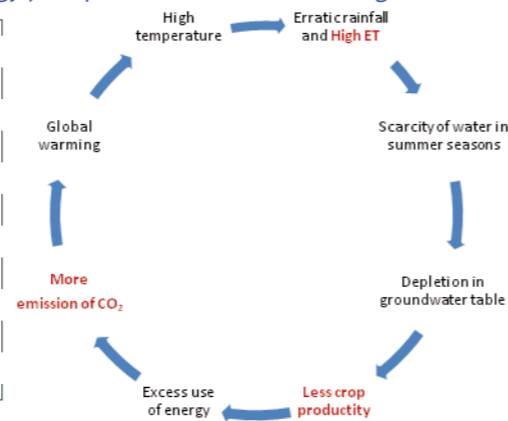
## 4. LINK TO THE ENERGY, FOOD AND WATER NEXUS

Around the year 2000, Indian farmers lifted some 150 km<sup>3</sup> of groundwater using electric pumpsets and around 80 km<sup>3</sup>, using diesel pumpsets<sup>10</sup>. It is estimated that the carbon emission from only groundwater irrigation is about 16 million metric ton, roughly 4% of India's total carbon emissions.

In addition, due to climate change, it is predicted that there will be prolongation in dry spells and increase in the intensity of rainfall with torrential runoff. This will affect the soil moisture status and crops may undergo physical stress. Increase in temperature will reduce soil moisture during non monsoon seasons due to increase in potential evapo-transpiration (Mall et al., Current Science, 90: 2006). It is predicted that there will be decrease in winter precipitation by 10 to 20% over central India. (Lal. M., Current Science 81: 2001). There will be increase in dry spells in central and western part of India by 2050 (Rupakumar et al., 2003). There will be over all increase in the rainfall approx. by 20% but the melting of glaciers of Himalaya will be cause of concern for northern plains (Mall et al., Current Science, 90: 2006). There will be increase in the precipitation in the Mahanadi, Ganga, Godavari and Cauvery valleys but there will no change in total volume, due to increase in ET on account of increased temperature (Gosain and Rao, 2003). Drop of 1m in groundwater table after water withdrawal will increase India's CO<sub>2</sub> emission by 1%. (Mall et al., Current Science, 90 2006).

Nexus between water-energy-food production in climate change scenario :

In India about 52% of its total electricity is generated using fossil fuel (coal). Indian agriculture consumes about 30% of its total electricity. According to BERI (2007), India is among top 10 fastest growing economies in the world. Due to this its fossil fuel share is expected to rise to 74 per cent of total energy by 2010, the corresponding increase in CO<sub>2</sub> emissions being 1,646 Million tons. The use of fossil fuels increases the Greenhouse gases (GHGs) emission. Thus, energy efficiency and increased water productivity in agriculture has huge impact on water and energy policy in India.



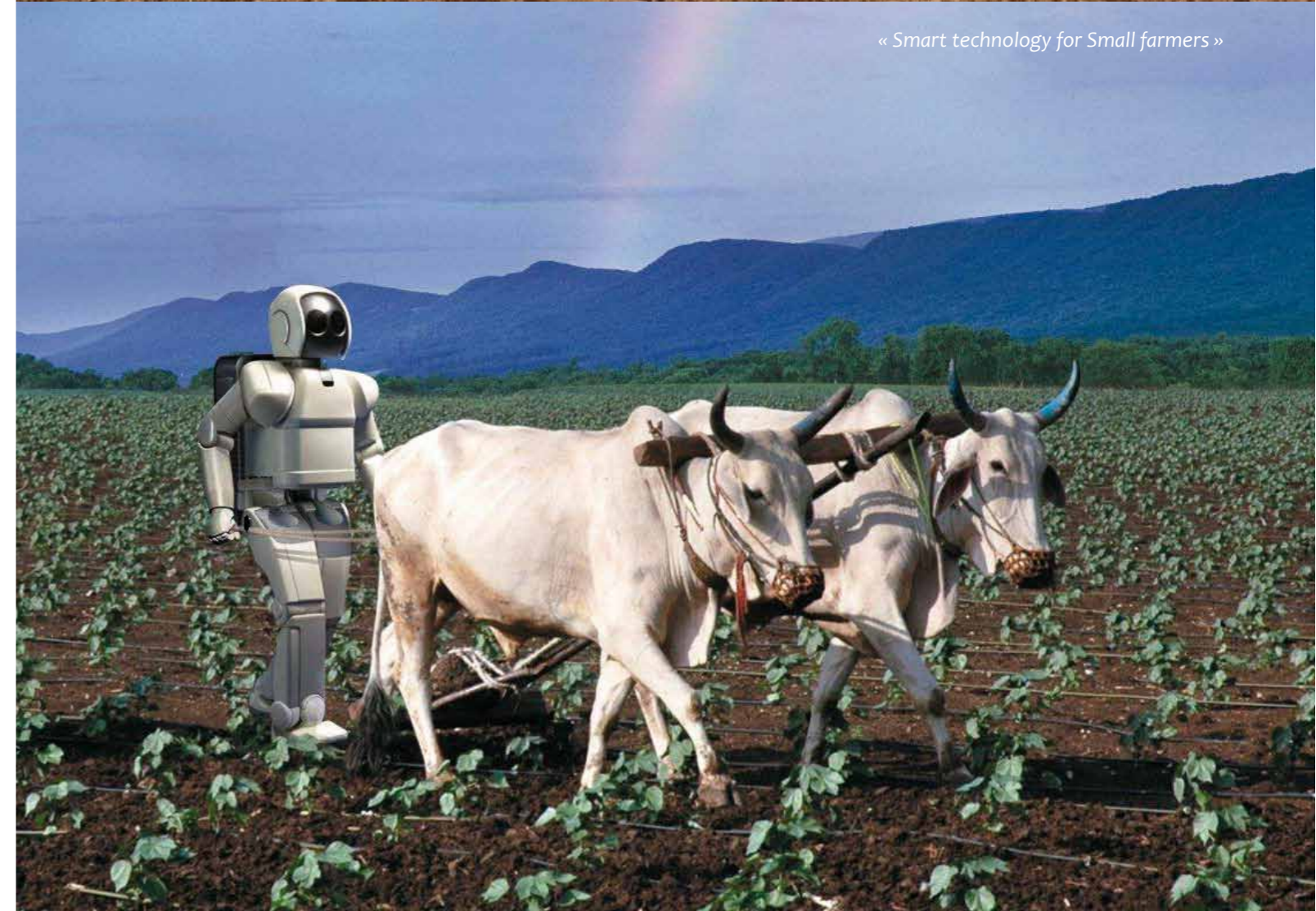
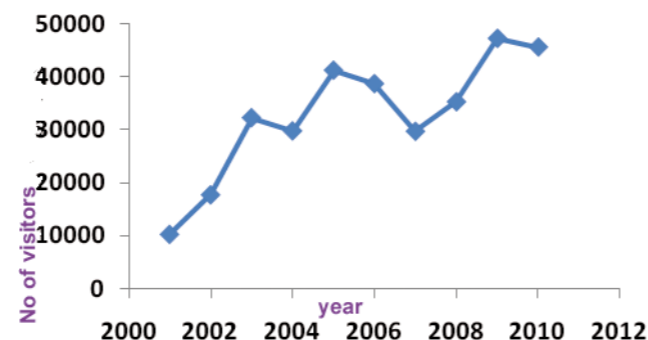
Ultra High Density mango plantation

## 5. PROCESS, SUMMARY OF ACTION TAKEN

The cost of drip irrigation per acre of farm is different and depends upon many factors, such as spacing, crop geometry, topography and soil type, water source, crop type. Other problems associated with drip irrigation are the acceptability or penetration of technology is very slow, despite of, lot of efforts made, even the subsidy factors plays important role. The maintenance of the system requires technical know how. To overcome these problems Jain Irrigation provides training to staff and after sales service to farmers.

At the JISL, farmers and other stakeholder are trained with in-house training facility of sprawling 1800 acres Jain R&D farms in Jalgaon Maharashtra and Jain R&D farm at Udumalpeth, Tamil Nadu, and India. They are undertaking research trials and demonstration jointly with Agriculture Universities and Innovative Farmers along with their own farms. Till date more than hundred thousand peoples have visited and got trained at R&D and demonstration centre at Jain Hills, Jalgaon India facility from last 15 years. This had a spiralling effect on the thought process of even the policy makers and farmers at last, "seeing is believing".

No. of visitors including farmers, officers and others visiting at Jain Hills, Jalgaon



« Smart technology for Small farmers »





### 6. PLANNING AND BUDGET

JISL is more concerned about penetration of the technology horizontally (acres' covered) and vertically (number of irrigated crops by drip irrigation system). It is very important to have a versatile strategy for various crops and under different agro-climatic zones. For that matter we need to work with the famers, agricultural universities, state and central government to cover that particular crop under government subsidy scheme. Thus we utilise the present infrastructure of our extension workers. But this is not sufficient, now we are planning expand our networks by employing the local person with minimal critical training to work as village level extension worker, and this will be the network of 1000 foot soldiers working closely with the famers. We have plan and already selected over 200 such associates to join the team.

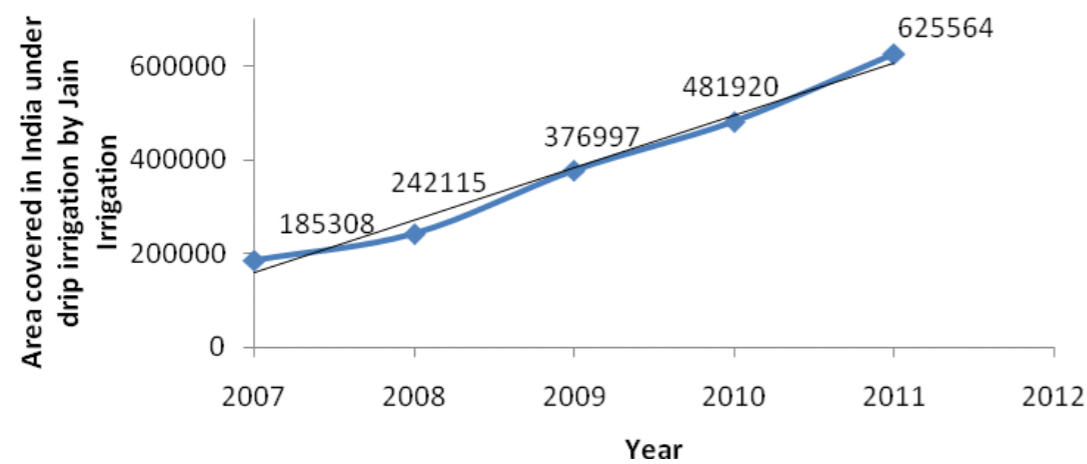
### 7. FUTURE COMMITMENTS

Future plans are to cover maximum crops under drip irrigation, in addition to continuous refinement and improvement of our existing practices. JISL would also like to develop viable technologies for rain-fed agriculture to increase the productivity of land and water resources. This will be done through integrated approach of rainwater harvesting, storage and better irrigation management methods. Use of solar energy for drip irrigation is high on our agenda. This technology can be very effective in arid regions of India. The use of biotechnology for pomegranate and sweet lime for different geographical areas will also be implemented soon.

### 8. RESULTS TO DATE

With continuous R&D efforts and engagement with farmers, JISL has encompassed almost all crops, under micro-irrigation technologies (e.g. drip irrigation, sprinklers). Experimental results are also quite encouraging for water intensive crops such as rice.

The adoption rate of micro-irrigation technologies is increasing and today nearly 5% of area out of irrigated land is under micro-irrigation. Market share of JISL in drip irrigation technologies is over 60% in India. Total area covered under drip irrigation by JISL is shown in the below figure. Also, it is worth mentioning that JISL has launched the new technology for arid area with solar pump and drip irrigation. To break the perfect nexus of water-energy-food, this will be great boon, if drop by drop water is provide to the root zone without wastage of water, with great efficiency, saving electricity (or providing electricity where there is no electricity by solar pump technology) and producing more from less area or producing good crops where it was only rain fed crop.



Demonstration and extension service at farmer's field (contracts onion form)



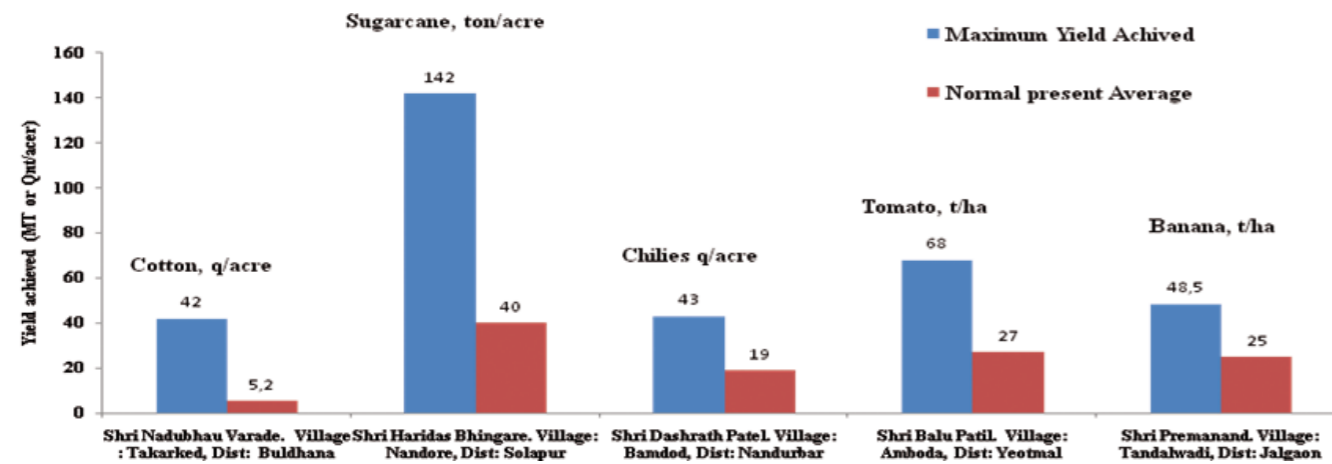
Extention for cotton on drip by Jain Irrigation



Our ultimately objective is to,

- Increase the productivity of the famers per unit are and per unit of water available.
- Penetration of adoption of technology to a large number of farmers.
- Increase the area under drip irrigation in India.
- Expand to other crops, which are not currently under drip irrigation through research and development.

Increase in the yield due to drip irrigation some live examples (Jains data source) :



### 9. LESSONS LEARNT

Having based in Maharashtra, we have expanded to other parts of India. There cannot be a one-size-fits-all solution in the country, as there is a great diversity in cropping patter, agro-climatic, hydro-geological and cultural conditions. We go to new places with an open mind and try to innovate new solutions to suit local needs. We bring in new crops into the scope of drip irrigation by incorporating necessary changes. For instance, drip irrigation for cotton (considered as dry land crop), pulses and oilseeds (trials are successful but still there is struggle to expand horizontally in acres covered under drip) and recent rice (successful trials which shows the reduction in water, energy and methane emission). Use of drip irrigation for water intensive crops such as banana and sugarcane is a history now.

We would like to share our experience with other developing countries having similar agro-climatic conditions. The key factors of success are the assiduous tasks JISL'S associates are handling and walking on the path shown by the vision of the founders "to leave this world better than we found" and lead in the world, in the any business venture we operate into.

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# CASE STUDY NEXUS

**BUILDING THE SUSTAINABLE DAM :**  
 the challenges of meeting energy  
 and livelihoods objectives  
 at the same time

/ SOUTHEAST ASIA /



## 1. DESCRIPTION OF THE ACTORS

The Ministry of Energy and Mines, Vientiane, Lao PDR – key Lao government partner in the project.  
 The TheunHinboun Power Company, Vientiane, Lao PDR – dam owner and operator.  
 Statkraft, Oslo, Norway – 20% shareholder in the project.  
 Electrcite du Laos, Vientiane, Lao PDR – 60% shareholder in the project.  
 GMS Lao Company Ltd – 20% shareholder in the project.  
 Affected communities of the Bolikahamxay and KhammouanneProvinces, Lao PDR – project affected

## 2. BACKGROUND TO CASE

The Nam TheunHinboun is one of the largest dams in Laos, the so-called ‘battery of Southeast Asia’. This run-of-the-river dam was commissioned in 1998, has 210 MW installed capacity, generating some 1,500 GWh per year, 90% of which is destined for the Thai energy markets. The plant exploits the altitudinal variation between the Nam Theun (from which it derives its water supply) and the Nam Hinboun (in to which water is emptied having passed through the plant’s turbines). The dam is currently expanding its operations – the so-called Theun-Hinboun Expansion Project (THXP), which will increase installed capacity by 60 MW.

The plant was built with funding from the Asian Development Bank, and therefore subject to its hydropower guidelines and protocols. At the time, these were based on EIAs, with little provision for longer-term social investment and development. Since the dam’s commissioning, however, the Theun-Hinboun Power Company has seen that a commitment to a variety of social and environmental policies are beneficial to its corporate social responsibility profile, the dam’s overall public image (something that matters to shareholders), and its own national profile in Laos. Since its inception, the project has become one of the foremost global leaders in resettlement. Its attention to extensive consultation and preparatory studies has meant that the project has become a national leader in resettlement plans, as well as environmental management. The resettlement plan under the THXP will affect 4,000 people.

## 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

At the best of times, hydropower is controversial. One of the areas in which such developments are most critiqued is in the area of resettlement. ‘Livelihood reconstruction’ (as the World Bank calls it) is at the best of times a difficult process. Nam TheunHinboun has sought to meet the concerns of its critics (and, indeed, the expectations of its shareholders) by embarking on pre-emptive livelihoods reconstruction. Its resettlement and environmental plan has the following objectives:

- Identify all direct and indirect impacts of the project.
- Working closely with technical planners and engineers to avoid and reduce impacts wherever possible.
- Full mitigation of all unavoidable impacts through compensation, replacement, resettlement and relocation programs.
- The design of a thorough monitoring system with clear targets for full restoration of all households to be relocated or resettled.
- Implementation of social programs in close cooperation with project affected people and government organisations through consultations, disclosure or entitlements and reporting to all stakeholders.
- Implementation of environmental programs to protect the local environment and enhance conservation and reforestation programs to offset and construction and operation impacts.



## 4. LINK TO THE NEXUS

The approach taken was to open up opportunities for the resettled households across a spectrum of livelihoods options, comprising health, education, agriculture, housing and development infrastructure, such as energy. When resettlement is necessary, thought and managed through the nexus interlinked process is a key factor of success to achieve it in optimal conditions for people resettled.

## 5. PROCESS, SUMMARY OF ACTION TAKEN

Implementation of the plan comprised a five-aspect approach:

- Regional health programs covering refurbishment of existing health posts, vaccination, mother-child care, sanitation, health awareness, and other government health programs not being implemented due to lack of resources.
- The Social Management Action Plan, which included anti-trafficking, your awareness programs, STD awareness, and community strengthening to prepare ‘host villages’ proximate to the construction areas to receive resettled villagers.
- Full asset registration and consultation so as to fully compensate resettled households for land and assets lost as a result of the project.
- Development of a full set of procedures and standards for environmental compliance in preparation for discussions with contractors and for joint site inspection of construction sites.

Uniquely, the project engaged with the World Wildlife Fund (WWF), the World Conservation Society (WCS) and Save the Children (Norway) to bring in fresh ideas and guidance as they implemented their resettlement, environmental and social plans.

## 6. PLANNING AND BUDGET

The social and environmental plans represents about 10% of the total THXP project budget of US\$650 million.

## 7. PROBLEMS, DIFFICULTIES MET

In resettling 4,000 people, the company has had to contend with 4,000 variables. Under any circumstances, this is a challenge, and the company has dealt with most of the innumerable problems thrown up by this variability by constantly monitoring and evaluating resettlement and the progress of individual household livelihoods.

## 8. RESULTS TO DATE

Resettlement occurred at four sites around the anticipated inundation area. Each resettled household received a new house, 1,000 m<sup>2</sup> plots for agriculture and livestock, a hectare of land for rice cultivation and a half-hectare of upland fields for the cultivation of cash crops.

In addition, resettled communities have been given access to grazing areas, forests, rivers and fish ponds. Their health and education facilities have improved, and they have benefited from improved access from roads to and from key market towns. Individual households have also benefited from receipt of tools, technical assistance and other equipment.

The project invested heavily in the identification of suitable sites for villagers, and resettled villagers were paired with existing villages of the same ethnic group so as to improve the likelihood of integration, and hasten the process of integration. These preparatory studies also established baselines, which underpinned the company commitment to resettled communities.





Resettled household livelihoods need to achieve a target of US\$1,800, while relocated households a target of US\$1,450 for two consecutive years before the company withdraws its support. These targets are 25-40% above existing income levels.

#### 9. LESSONS LEARNT

Successful resettlement that successfully addresses the matrix of livelihoods, energy, hydropower and food can be achieved provided it is focussed on clear targets, and investment in process and monitoring. There is no blueprint for successful resettlement, but there are frameworks that can be employed and replicated anywhere in the world. A strong corporate commitment to social responsibilities is an essential ingredient in this mix.

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# CASE STUDY NEXUS

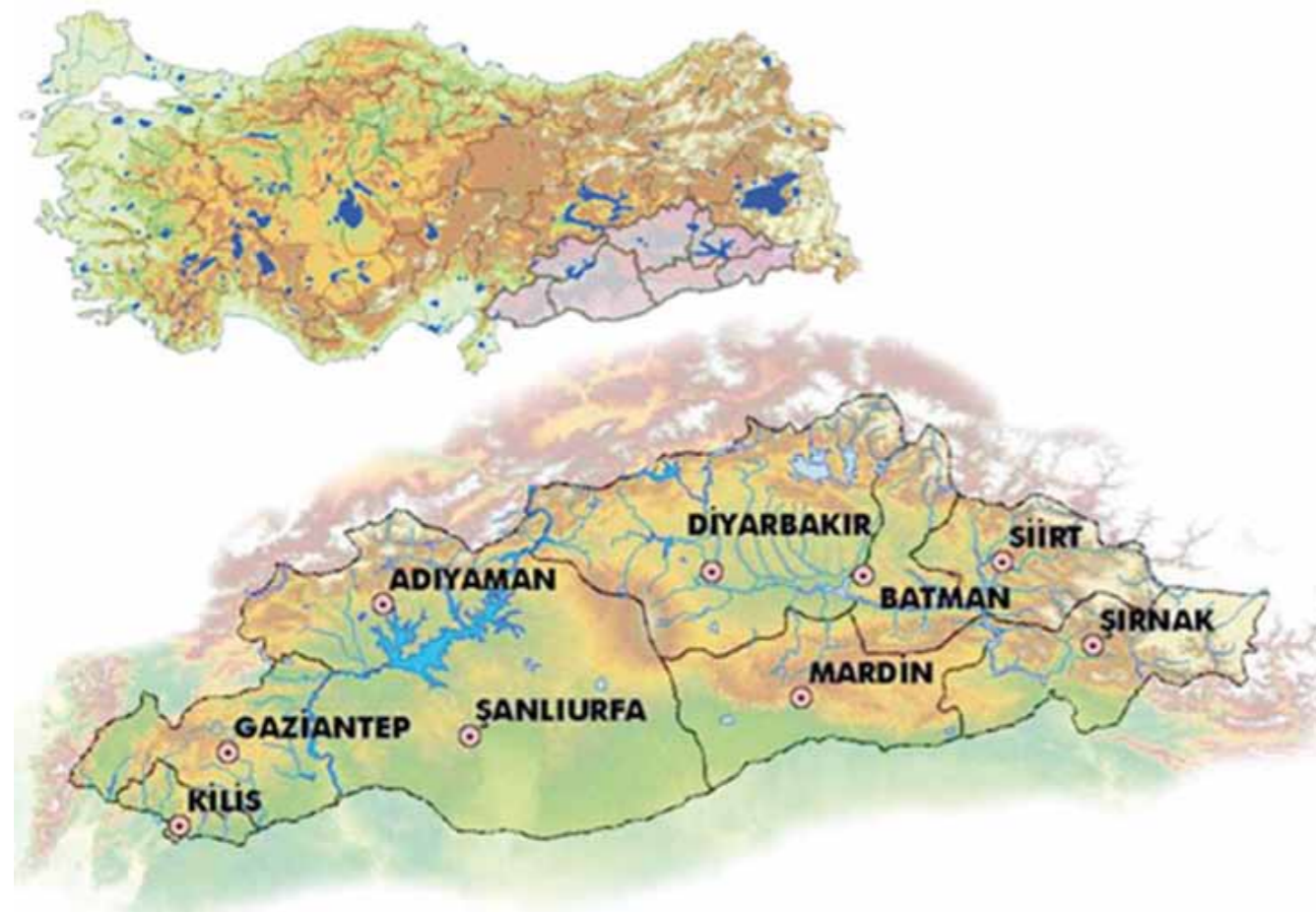
## THE SOUTHEASTERN ANATOLIA PROJECT (GAP) : An Integrated Approach to Irrigation and Hydropower Development

/ ASIA /



## 1. DESCRIPTION OF THE ACTORS

The Southeastern Anatolia Project (GAP, Turkish acronym) is a multi-sectorial and integrated regional development programme prepared towards the improvement of Turkey's least developed region. The development programme covers 9 provinces in Southeastern Turkey and aims to facilitate social and economic development in the sectors of irrigation, energy, agriculture, rural and urban infrastructure, forestry, industry, education, health, transport, etc.



GAP is not just a public project; it involves a broad spectrum of different actors and non-governmental organizations (NGOs) working in collaboration. The GAP Action Plan involves a total of 52 public institutions in charge and 82 partner organizations to be cooperated (public bodies, NGOs, local authorities, universities, etc.). The main actors include the Southeastern Anatolia Project Regional Development Administration (GAP-RDA), State Hydraulic Works of Turkey (DSI), Ministry of Energy, Ministry of Food, Agriculture and Livestock, Ministry of Development, Regional Development Agencies (RDAs), Water Users Associations (WUAs), agriculture cooperatives and many other stakeholders all involved in the organization.

DSI was responsible for the operation and maintenance (O&M) of the irrigation system constructed in the project at the initial phase of the process. In the later stages WUAs (as of 2010, 60 associations in the region) were put into operation in order to improve the efficiency of O&M services. This responsibility transfer reduced farmers' complaints and increased efficiency of water use in the agriculture. Also, this participatory approach by the users generated a sense of responsibility for better use and protection of the resources and the facilities. Overall, irrigation efficiency has increased and energy consumption decreased by 25 – 45 %.

One of the development axis of the Project is “building institutional capacity at local level”. Means of local administrations in terms of service delivery and contributing to development process have been enhanced; growth of private sector companies, professional organizations and NGOs are supported and the social and institutional capacity of the region is enriched.



Below are some examples of institutional arrangements that helped to overcome “silo” thinking:

- Capacity and effectiveness of the Turkish Employment Institution (İŞKUR) is enhanced to improve the quality of labour force in the region, impart occupational skills and to train labour force required by agriculture, industry and service sectors.
- GAP Banking School has been established. In this context, Ziraat Bank (that supports agricultural activities) trained 551 qualified personnel to contribute to banking activities related with agriculture in the region.
- Public Internet Access Centres were expanded in both rural and urban areas. Centres endowed with hardware, software, network base and physical qualifications are established and operated in cooperation with local entrepreneurs RDAs, Governorships, Municipalities, NGOs, Private Sector.
- State Planning Organization (SPO) has established regional development agencies in many provinces in cooperation with GAP-RDA.
- Institutional capacity of the Ministry of Food, Agriculture and Livestock in the region has been strengthened. In this regard, GAP International Research and Training Centre in Diyarbakir and Irrigation Training Centre in Şanlıurfa have been established to conduct research and development for irrigated farming.
- GAP-RDA has been moved from Ankara to the region to improve monitoring, evaluation and coordination capacity of the GAP Administration for successful implementation of the GAP Action Plan.

## 2. BACKGROUND TO CASE

Beyond an infrastructure project consisting of only energy and irrigation investment, GAP is now addressed as an integrated regional development programme mobilizing local initiatives also by making use of the joint cooperation platform of prospective development agencies. In this context, application of modern irrigation techniques, completion of transportation and housing infrastructure, transition to competitive product types, expansion of marketing policies, development of human resources and institutional capacity and taking advantage of natural and cultural fabric are among new policies geared to support economic and social development so as to make the region more competitive in many respects. The project rests upon the philosophy of sustainable human development, which aims to create an environment in which future generations can benefit and develop. The basic strategies of the project include fairness in development, participation, environmental protection, employment generation, spatial planning and infrastructure development.

- The GAP region has a share of about 10 % in both the total population and geographical area of Turkey.
- 20% of total irrigable land in Turkey falls within this region and the region represents 28% of Turkey's total hydraulic potential mainly with the Euphrates and Tigris rivers.
- The total cost of the project is estimated as 30 billion USD in 2011 prices.

Before the launch of the project, the GAP region was tackling some important problems such as unemployment, lack of skilled labour force, insufficient education services, low level of education, lack of health facilities and services, bottlenecks in access to water, lack of industrial and energy infrastructure, and low level of regional capital accumulation. At the inception stage, GAP was launched as a programme for developing land and water resources existing in the region. As an example for the social development indicators, the literacy of women in the region has increased from 40% to 72% between the years 1985-2009. To protect the precious water resources and maintain the ecosystem services, wastewater treatment plants were constructed or upgraded. The solid waste fields in the region were rehabilitated.

Being in a region including transboundary rivers, GAP has the following impacts on the region:

- Benefits of agricultural production is not only limited to Turkey, but also shared with Iraq and Syria through extensive export of food products,
- As a result of the project, the export of the region to neighbouring countries increased from about 7.1 million USD in 2001 to 7 billion USD in 2011,
- In the framework of the project, 15 dams were constructed on the Euphrates and Tigris Rivers. The benefits of these dams to the region include regulation of water and provision of a constant water flow during times of drought and flood. Energy production necessitates release of water at a regulated flow rate to downstream neighbouring countries.



### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

GAP is an integrated socio-economic development project. With the preparation of the GAP Master Plan in 1989, the project was transformed into an integrated regional development plan also covering such diverse fields as rural and urban infrastructure, housing, transportation, communication, agricultural and industrial development. The main objectives of the GAP are to increase the economic conditions and well-being of the local people as well as the efficient utilization of the water potential of the region for food and energy production.

Some objectives and targets of the project are;

- Constructing of 22 dams and 19 hydraulic power plants
- Having capacity to produce annual energy production of 27 billion kWh
- Creating 1.82 million hectares of irrigated land
- Increasing Gross National Product (GNP) by 445%
- Increasing per capita income by 250 %
- Increasing income per hectare by 275%
- Educating 35,000 workforce
- Providing education and consultancy to 6,000 business owners
- Constructing 22,000 new housing
- Constructing wastewater treatment facilities and network for 121 municipalities
- Constructing additional drinking water networks for 67 municipalities

### 4. LINK TO THE NEXUS

The main aim of GAP is to convert the region into a base of agricultural export through developing agro-industry in the region. Investing in energy and agriculture is equally important as they are interrelated. As far as irrigation investments under GAP are concerned, priority was given to water storage. Until now, 15 dams have been completed and a water holding capacity sufficient for irrigating 366,000 hectares of land was created. This means that only 20% of all targeted irrigation investments and 74 % of hydropower generation could be realized so far.

From an external perspective, the rate of development in energy production is higher than that of irrigation systems. The main reason behind this is that energy production can more easily be realized in terms of time and resources. However, development of an efficient and rational irrigation system necessitates many socio-cultural and technical improvements (education of farmers, adaption of new irrigation technologies) and the results of this process can be observed after a longer period of time. This delay in the development of irrigation systems brings forward the increase in energy production.

Competition over water consumption for hydropower generation, irrigation and industry was not experienced in the region. The number of industrial enterprises in the region has almost doubled from 2002 to 2010. The total exports from the region which consists of agricultural products increased from 34 million USD in 2002 to 1.7 billion USD in 2011.

### 5. PROCESS, SUMMARY OF ACTION TAKEN

By the end of 2010, construction of 10 hydraulic power plants was completed in the region. This means that about 74% of envisaged energy projects have been realized. So far, 366,000 hectares of land was brought under irrigation in the region. Significant developments have taken place in industry in the region following the start of irrigated farming. The number of industrial enterprises in the region has almost doubled from 2002 to 2010. By the end of 2010, there are 2,227 enterprises in the region each employing more than 10 workers. In these enterprises 127,445 people are employed. The target of the GAP was the economic and social development of the region. As a result of the project, the added value of the region has been increased from 3.84 billion USD to 17.1 billion USD. The seasonal migration rate from the region decreased from 70% to 11% and total migration rate has reduced by half from 2008 to 2010 as a result of irrigation projects. The ratio of the region's export to the total export of Turkey increased from 1.9 to 5.1 within the last 10 years.



## 6. PLANNING AND BUDGET

Under the master plan, funds needed for foreseen public investments in the region reached approximately 30 billion USD in 2011 prices. By the end of 2011, total spending amounted to approximately 25 billion USD, thus giving the rate of cash realization as 87%.

## 7. PROBLEMS, DIFFICULTIES MET

Contemplated targets could not be reached in terms of capacity building and training of the local actors, mainly the farmers. More time will be needed to familiarize local actors with the advanced irrigation techniques. Delays were experienced in realizing improvement in irrigation systems due to the fact that the realization of this process necessitates time consuming activities like capacity building and education of farmers. Energy production, on the other hand, requires less capital cost and time than agricultural improvement.

There are no significant inter-sectorial tensions or competition for limited resources concerning energy and food production. Rather than competition between irrigation and energy production, majority of the concerns were related to the protection of cultural heritage, resettlement and environment. Such issues caused delays mainly in the implementation of energy generation targets.

## 8. RESULTS TO DATE

- GAP produced 17.3 billion kWh in 2011, which constitutes 47% of Turkey's total capacity of 36.7 billion kWh of hydro-energy.
- Today the contribution rate of GAP to Turkey's total electricity production is 7 %.
- In 2010, the proportion of the volume of export originating from the GAP region within Turkey's total exports was 4.5%. Processed agricultural products are taking the lead with 42% of the total exports.
- Financial outcomes of the project includes increase of per capita income from 603\$ to 1515 \$, increase per hectare income from 667\$ to 1674 \$.
- Some of the examples in relation to social development in the region include projects for increasing empowerment of women, youth and children. Multi-purpose community centres were established. Youth centres and children's learning centres were opened.

## 9. LESSONS LEARNT

- Achieving improvements in irrigation require more efforts and longer amount of time and therefore planning of irrigation system should start at the same time with the construction of dams for energy production.
- Agricultural benefits of the region may contribute to the food security of not only Turkey, but also neighbouring countries as a whole.
- Enhancing hydropower capabilities through the construction of dams and hydropower plants offers considerable benefits especially in such semi-arid regions with low precipitation rates. Producing energy through hydropower does not consume and pollute water compared to other conventional energy generating methods.
- The project may constitute an example for immense IWRM projects on regional scale.
- Multiple factors of agriculture, energy and socio-economic conditions may be rehabilitated through a holistic perspective.
- Introduction of WUAs increased the efficiency of water use in agriculture.
- Economic development of the region and new employment opportunities contributes to the return of the locals who have emigrated to other regions.
- Energy efficiency, reuse of agricultural by-products, using modern irrigation systems for less water consumption is essential to save the resources and minimize losses.
- Preserving nature while sustaining productivity in the region is of great importance. Shifting from conventional agriculture to organic agriculture and using renewable energy instead of conventional energy contributes to the preservation of ecosystems and biodiversity.

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# CASE STUDY NEXUS

FROM SERRE-PONCON (France)  
TO NAM THEUN 2 (Laos) :  
Back to a sustainable and  
multi-purpose future integrating  
water, energy and food needs

/ EUROPE & ASIA /





# case 7



## 1. DESCRIPTION OF THE ACTORS

It was through the “Serre-Ponçon and «Lower Durance» development” Bill of 5th January 1955, voted in almost unanimously by both Assemblies, that the State declared the public value of the Durance development project, the construction and operation of which it entrusted to EDF. The upstream 324 MW Serre-Ponçon scheme was commissioned in 1960. The other main stakeholders are: Water Agency, Local Commission for Water, Fishing French Federation, Kayaking French Federation, Local farmers, Local Tourism businesses, ...

The 1070 MW Nam Theun 2 (NT2) hydropower project originated in a protocol signed between the Lao and Thai Governments. That agreement stipulates supply by Laos of 5000 MW to the Energy Generating Authority of Thailand (EGAT) to meet that country’s rapidly growing needs for electrical power. The electricity is provided both to EGAT (Thailand consumption) with 995 MW (and to Electricité Du Laos - EDL (for local consumption) with 75 MW. Developed and built by EDF under a BOOT (Build, Own, Operate, Transfer) process, in association with regional firms, the scheme was commissioned in early 2010. The owner and operator, NTPC (Nam Theun 2 Power Company Ltd), is composed of 3 shareholders: EDF International (40%), EGCO (35%-Electricity Generating Public Company -Thailand), LHSE (25% - Lao Holding State Enterprise - fully owned by the Government of Lao PDR).

Financers are also key stakeholders in this project. The US dollar senior debt facilities include political risk guarantees from the Asian Development Bank (ADB), the World Bank and the Multilateral Investment Guarantee Agency (MIGA), export credit agency support from COFACE of France, EKN of Sweden and GIEK of Norway, and direct loans from multilateral and bilateral development agencies including the ADB, Nordic Investment Bank, Agence Française de Développement (AFD), PROPARGO and the Export-Import Bank of Thailand. Nine international commercial banks and seven Thai commercial banks are providing long-term loans to NTPC.

## 2. BACKGROUND TO CASE

From a long time ago, EDF has developed hydropower with a specific attention on water resources management. For example, the Serre-Ponçon dam, commissioned in 1966, is the most outstanding architectural structure of the multi-purpose Durance and Verdon River system. With 32 hydropower plants, it enables the production of 6.5 billion kWh of renewable electricity and an output of 2000 MW within 10 minutes, supplies drinking water and water for industrial purposes to an entire region and irrigates over 150,000 hectares of farmland with a guaranteed storage of 200 million m<sup>3</sup> in summer. The regulation of water flow and irrigation allowed the development of agriculture in the downstream areas. The reservoir of Serre-Ponçon became a lake on which activities were developed, and for instance, the average turnover from Tourism (fishing, sailing, water-skiing, swimming, cycling ...) is about 100 to 150 M€ a year nowadays. An innovative consultation process was also a key issue to gain the acceptance of local population.

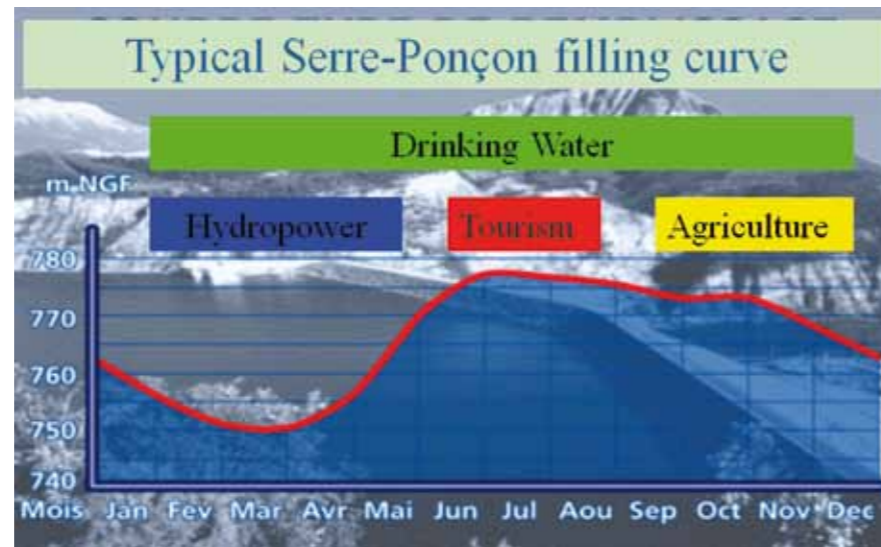
More recently, with the same philosophy of optimizing the multi-purpose of water, EDF developed and built the 1075 MW Nam Theun 2 hydropower scheme in Laos. It is a trans-basin project (partial water diversion from Nam Theun river to Xe Bang Fai River) with 1070 MW installed capacity under 350m head. It creates a 450 km<sup>2</sup> and 3.5 billion m<sup>3</sup> reservoir by means of a 45m high dam. Power generation, irrigation, flood control, clean drinking water, access to reservoir for fishing, boating, ... are the different benefits of the scheme which is a major contributor to the socio-economic development of this region including Thailand. Indeed, NT2 originated in a protocol signed between the Lao and Thai Governments.

That agreement stipulates supply by Laos of 5000 MW to the Energy Generating Authority of Thailand (EGAT) to meet that country’s rapidly growing needs for electrical power. The electricity is provided both to EGAT (Thailand consumption) with 995 MW (5635 GWh/year) and to Electricité Du Laos - EDL (for local consumption) with 75 MW (200 to 300 GWh/year). A high level of public consultation and disclosure has been a priority to ensure that all affected people are fully informed of the Project and that their views are taken into consideration. Over 250 public consultations and workshops were organized at all level (local, national, regional, international). Nam Theun 2 has benefited and continues to benefit from a level of consultations within Laos that has not been seen before, between the local government, project developers, the Project Company and the World Bank.



### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

Hydropower is the major contributor of renewable energy and was responsible for 90% of the world's renewable electricity production. The development of a hydro project is sustainable if social and environmental issues are properly treated and is a powerful tool for local and regional development and also for fighting against poverty and global warming. As part of its commitment to a sustainable development approach, the EDF Group seeks to balance economic development with a high level of service, environmental protection and social equity whatever the location in the world.



All members of Parliament were in agreement about the great importance of the Durance project and of the Serre-Ponçon dam, the keystone of this development plan. Despite the large environmental and social impacts, at no point was the project brought into question because development was the main driver and advantages were higher than drawbacks, despite widespread criticism at the time of EDF's "fully-hydraulic" policy. Falling under the umbrellas of both energy policy and town and country planning policy, the development of the Durance, which would lead to the destruction of two villages, was supported by most of the different actors. In the minds of those in charge of the project, the aim was to boost the development of the region as a whole and to modernise its valleys, even at the cost of its village communities. And this was confirmed during the various debates triggered by the draft Bill on the development of the Durance. Indeed, given all the contradictory interests at stake, it seemed crucial to the authorities and to EDF that the country's interest in the project should be expressed by a public vote at the National Assemblies.

In Nam Theun 2, the approach was a step by step approach with some difficulties at the beginning of the project to define the level of environmental and social requirements in a country where standards in these fields are poor or inexistent. It last about 3 years to have comprehensive studies on these aspects. The project has been identified as one of the best hydro projects in Laos in terms of benefits sharing, including water, energy and food resources optimisation and an attractive economic rate of return for the investors. NT2 project is also a unique approach towards environmental and social management: Comprehensive environmental and social impact assessments have been carried out and extensive socio-economic surveys have been performed regarding both the population living in the future reservoir area and those living downstream.

### 4. LINK TO THE NEXUS

The management of the Serre-Ponçon reservoir has multiple objectives – electricity production, flood amelioration and water for irrigation. Tourism is not a contract condition but is also included in reservoir management objectives. EDF is required to deliver 200 Mm<sup>3</sup> to irrigators between 1st July and 31st September annually, and an information bulletin is sent each week to farmers about irrigation flows.

EDF encourages farmers for saving water by financing modern systems for water use reduction. Through a specific agreement (Water Saving Convention signed in 2000), which leads EDF to payback a part of the saving costs if the targeted objectives are reached, the agricultural consumption for one partner decreased from 310Mm<sup>3</sup> in 1997 to 201Mm<sup>3</sup> in 2005. EDF, in association with the Water Agency, co-financed a number of environmental initiatives e.g. reforestation of upstream land. The Plan Durance reports on the implementation and effectiveness of these additional economic benefits.



In Laos, both reservoir area and downstream powerhouse area are concerned by water, energy and food issues. Often, compensation approach is used by developers, but in the case of NT2, the choice made was to use a more integrated approach embracing the different issues as described below, which allows for instance to save water from agriculture, to better manage flow streams in order to protect ecosystems downstream, to decrease energy needs for agriculture, ... To ensure sustainability: participation, sharing, technical assistance, training, communication, ... are also key issues. The creation of the Nam Theun 2 reservoir has flooded large areas on the Nakai Plateau and it was necessary to relocate 17 villages with 1100 households and 7000 individuals.

Before resettlement, households living on Nakai always had diverse livelihoods, which allowed them to cope with frequent shocks and to make the most of limited natural resources. They subsisted mainly by cultivating swidden upland rice, vegetable gardens and fruit trees, supplemented with fishing, livestock raising and collection of NTFPs (Non-Timber Forestry Product) and wildlife. Forty two percent of cash and in-kind incomes came from agriculture and 23% from livestock, with 16% from wages, food-for-work and jewelry sales, 10% from fishing and 9% from NTFPs and wildlife. The worst-off households had no land suitable for rice cultivation, and relied mainly on NTFPs for subsistence. Some households sold or bartered forest products, and occasionally livestock, to merchants in Ban Oudomsouk. However, at least 55% of household income was in-kind: crops produced and consumed by the household.

The post-relocation livelihood program was designed in consultation with the resettlers, bearing in mind the natural resources available to them, their skills, traditions and previous livelihood patterns. The pillars of the resulting livelihood program are: forestry, fisheries, agriculture, including livestock and cultivation, and off-farm income sources. Downstream the powerhouse, in order to reduce and mitigate impacts of a different flow regime on the local population, a Downstream Program has been set up. It is a USD 16 Millions multifaceted program, which design and implementation spans from 2006 to 2013. It covers all downstream areas, has been endorsed by the Government of Lao, and is jointly implemented by the Project Company and the local administration. It includes agriculture programme, rehabilitation of water systems for irrigation and flood control, technical and financial assistance for irrigation pumps, ...

### 5. PROCESS, SUMMARY OF ACTION TAKEN

The construction of Serre-Ponçon dam led to the flooding of 2 825 hectares of land – 600 hectares of which were cultivable – and had a major impact on the villages of Savines and Ubaye, resulting in the resettlement of over a thousand inhabitants. Many buildings were destroyed, including two industrial facilities, and in addition, 60 km of road and path and 14 km of railway were lost. Population displacement was a key issue for the construction of the dam (around five villages), with around 15,000 inhabitants affected and 2,000 relocated. A three-year public consultation process was undertaken, with a large proportion supporting the dam and compensation (new houses, land, new roads) negotiated with those communities that were to be affected.

Only three villages were against the proposed dam. This process was very innovative on that time for this kind of project. The consensus that formed around the desire for modernity and greater well-being, as well as the will to break into a new era, led to fundamental changes in the local communities after the dam was built. Although the majority of inhabitants chose to leave the area, they all picked very different destinations. By changing locations, these farmers left behind the peasant life and entered the world of modern agriculture. A break therefore occurred both with the area itself and with the previous era, with the common aim of achieving social advancement. One of the major trade-off was the decision to set aside part of the Serre-Ponçon reservoir for the storage of 200 million m<sup>3</sup> of water for agricultural purposes.

For NT2, all obligations and measures needed to mitigate the Project's impacts or to compensate the population have been identified in the expert studies and have been contractually sealed into the Concession Agreement signed between the developers and the government of Laos. The approximately 1,100 households or 7,000 people, whose current villages are situated within the area of the future reservoir, moved in a maximum 5 km area from their original habitations. New housing, schools, health and community infrastructure complete with electricity and water supply were constructed. The primary water supply activity was the construction of around 500 deep boreholes which are equipped with AfriDev hand pumps, prior to the beginning of operation.



The Downstream Program is also conducting demonstration activities within each district as part of developing the operation and maintenance program for water supply. As part of the demonstration activities water users are trained on how to operate and replace degenerated parts, given tools and basic spare parts and a handbook on how to maintain and repair the hand pumps. While gaining land ownership, each household is given a variety of livelihood opportunities, including agriculture, forestry, reservoir fisheries, livestock, and community-based commercial activities. NTPC has provided resettled households with both technical assistance, through extension workers and demonstration plots in each village, and free or subsidized inputs including agricultural tools, fertilizer and improved crop varieties. Households have been able to choose between several different technical systems. Although soils on Nakai are relatively poor, an agricultural system combining rotation of crops with legumes (particularly stylo, or “tropical alfalfa”) with use of fertilizers and improved crop varieties has generated yields of over 3 tonnes/ha, even on poor soil.

The 4,000 km<sup>2</sup> Nam Theun 2 forested watershed, which ensures a continuous supply of water to the reservoir, is controlled and managed by the Watershed Management Protection Authority (WMPA), established for that purpose, and funded by NTPC via a contribution of US\$ 1 million per year during the construction (5 years) and concession (25 years) periods. This world-class primary forest area is of key importance in terms of its biodiversity and is considered to be the largest untouched refuge of its kind in South-East Asia (elephants, tigers, Saola ...).

## 6. PLANNING AND BUDGET

It is difficult to calculate the original budget of the Serre-Ponçon dam which is including in a more larger valley development project. The economic performance is very good and increased by the indirect benefits from the scheme (irrigation, flood control, drinking water supply, tourism, ...). The project was voted in 1955 and commissioned in 1966.

The NT2 project construction started in May 2005, mobilising up to 8000 workers (75% of Lao workers), and was commissioned in March 2010. A total of US\$ 1.58 billion in capital commitments for NTPC was completed to finance the total base project cost of US\$ 1.250 billion, contingencies and ancillary bonding facilities. Around US\$ 180 million (13% of the global budget of the project) are devoted to environmental & social (E&S) issues from design to operation of the scheme. This value is higher than usual value for such a hydro project especially in a country where there is no specific regulation in regards to E&S standards. However, NT2 demonstrates it is possible to develop a hydro project with a good equilibrium between the 3 pillars of the Sustainable Development and the objective is now to replicate this new standard for other Lao projects in a shorter timeframe since benefiting from this unique and comprehensive experience.

## 7. PROBLEMS, DIFFICULTIES MET

With the multi-purpose uses of water in Serre-Ponçon, combined with a lake level agreement to keep the reservoir level at 780m at the beginning of July and >775m at mid-August, EDF sometimes has difficulties in meeting both these needs during dry years. All the objectives and plans were formulated by SDAGE (Management and Master Plan of Water) in 2001 and incorporated into the Plan Durance. These objectives have always been achieved, with regular reporting to stakeholders. The competing needs of various reservoir users has sometimes caused conflict, and after the low rainfall season of 1989-90 conflicts between stakeholders and anger at EDF lead to the formation of a new agreement which called for a better optimisation of the water level throughout the year to integrate the needs of all stakeholders. For this purpose, EDF also developed hydrological models and a dense network of sensors (discharge, snow, rain and temperature) which allow the hydric content of the Durance and Verdon basins to be assessed, together with any changes that occur and the volume of water supplied and discharged, weighted by a probability of occurrence.

Although the technical challenges have largely been overcome in Nam Theun 2, challenges remain. Perhaps the most important change required is a social one. The resettled households must now farm under significantly different circumstances to those they have adapted to over generations. Understandably, adoption of unfamiliar techniques and inputs is taking time to spread. Some households and villages are more willing than others to take risks by investing in new technologies. This means that some have achieved impressive yields, while others lag behind. For example, the best performing village in terms of yields has been Khon Kaen, a village towards the South of the plateau. The farmers of Khon Kaen had subsisted on the poorest soils in the plateau for generations, and were keen to take up new technology that would allow them to get as much as they could from every inch of land. This willingness to innovate has paid off.





Despite having some of the least fertile soils on the plateau, in 2008 Khon Kaen achieved an average rice yield of 2.4 tons/ha, more than twice the average.

## 8. RESULTS TO DATE AND FUTURE COMMITMENTS

During the last 50 years at Serre-Ponçon, EDF has reconciled electricity production with the expectations of all other partners and water users including that of tourism, a particularly active industry with high-growth potential for the regional economy. The shared management approach to 2002 and 2003's droughts highlighted that with high-performance forecasting and a strong solidarity between the different actors, notably from the Lower Durance agricultural community, and a thorough and regular dialogue it was indeed perfectly possible to enjoy the nearly limitless recreational activities offered by the 2nd Europe's largest man-made lake.

On a wider note, the ecological balance of the aquatic environment and the conservation of the countryside disrupted by the different hydropower stations along the Durance system make up both one of society's aims and a requirement of sustainable development. The main problems encountered after 50 years in this highly developed valley are morphological imbalances in the bed of the Durance and on the boundaries in wildlife development.

Downstream, phenomena of erosion, incision, paving, clogging and local draining-off can appear in the river. These phenomena can cause problems in terms of decreased biodiversity, the loosening up of the structure and the settling of the groundwater. Aware of the situation, EDF is now studying measures to operate differently the facilities while minimizing impact on environment. This requires the corresponding measures to be prioritized and jointly funded by all the partners (elected representatives and water users) committed to successfully conducting a Durance Plan steered by the State.

In NT2, the multipurpose use of water is a key element in the success of such a project and a good indicator of benefit sharing is the livelihood of the local people around the project. On the Nakai Plateau, households enjoy significantly higher incomes and living standards relative to the baseline. As well as improvements in economic indicators, they enjoy better access to health, education, water and sanitation. This has already led to demonstrably improved health outcomes and increased enrolment in school. As well as adding to household well-being, it is hoped that these investments in human capital will pay off in the long term, with increased and sustainable incomes. These improvements are clearly appreciated by the resettlers, and reflected in overall positive feedback on their new conditions and livelihoods.

However, building livelihoods is a complex and long-term process, and it is far too early to declare victory or sustainability. Although some encouraging results have been achieved on demonstration plots, progress in agriculture has been slow relative to fisheries. Households will need to adopt unfamiliar new techniques to realize higher potential yields. Off-farm income sources, particularly small shops, are beginning to replace wages from project related employment, which were available during the construction phase of the project. But the considerable potential for further development of off-farm livelihoods, including tourism, will not bring benefits to the majority of resettlers unless carefully managed.

Forestry is a major livelihood pillar, and particularly important for vulnerable households. Although significant progress has been made with the development of the Village Forestry Association, it is early days to judge whether this can provide a sustainable income source for resettled households. In addition, households are expressing concerns about declining availability of NTFPs. Potential negative effects on household well-being and nutrition must be carefully monitored, and ways of replacing this important livelihood component pioneered.

## 9. LESSONS LEARNT

Hydropower has a crucial role to play in the water, energy, food and climate change nexus as an integrator and an optimizer of the water resources in a sustainable way as demonstrated for many years in Serre-Ponçon and as shown nowadays in Laos. The key issue for successful projects is the continuous consultation and dialog with the stakeholders wherever you are (developed or developing country) and whenever you are (50's years, nowadays or tomorrow).

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# CASE STUDY NEXUS

**DEUS 21 =  
DEcentralised Urban  
Infrastructure System**

/ EUROPE /



### 1. BRIEF DESCRIPTION OF THE ACTORS

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB, Stuttgart, Germany  
 Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany  
 Municipality of Knittlingen, Germany

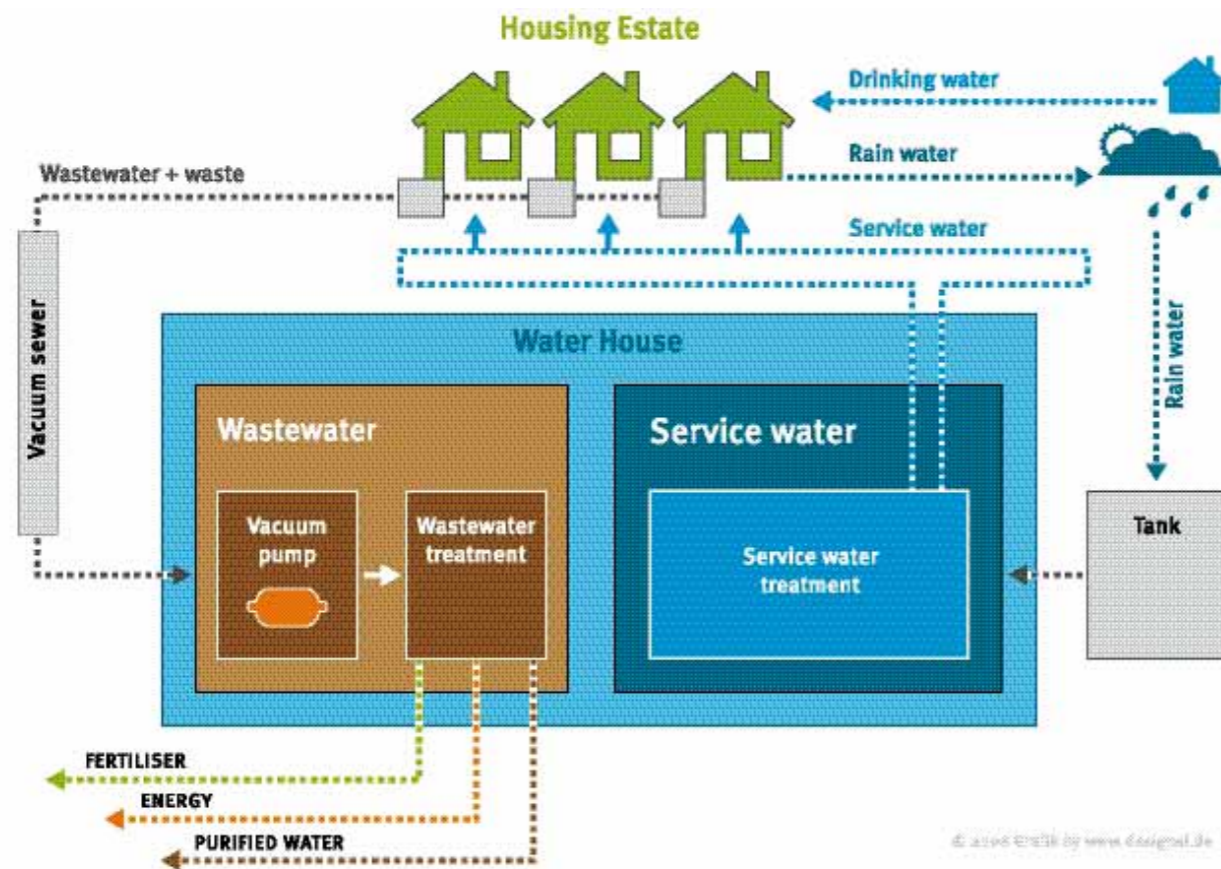
### 2. BACKGROUND TO CASE

The project was initiated in 2004. The contents were basically the conception, planning, implementation and optimization of a new water infrastructure system, containing water supply and waste water treatment. Rainwater (treated by membranes) is used as source for high quality water supply. The wastewater (incl. the biowaste fraction) is collected by a vacuum sewage system und treated in an anaerobic wastewater treatment. The outcomes besides the treated wastewater are nutrients and energy (biogas).

### 3. REASONS FOR ACTION, OBJECTIVES AND TARGETS

The aims of DEUS21 were to build up a resource-oriented, semi-decentralized approach in water supply and sanitation, which integrates the treatment of wastewater and bio waste in one single process, having as outcomes biogas, recycled nutrients and the treated wastewater.

Basic scheme of DEUS 21 :



### 4. LINK TO THE NEXUS

The outcomes of the DEUS-Process besides the treated wastewater are valuable products that can be used for energy generation and food production. Wastewater contains useful resources that should be recycled – the DEUS project is an approach to fulfil this target.

### 5. PROCESS, SUMMARY OF ACTION TAKEN

The DEUS 21 infrastructure concept consists of the following components and technologies :

#### Rainwater and non-potable water supply

Rainwater falling on the estate is collected in a subterranean system of storage sewers and fed into a modern membrane plant which processes the water to meet the German Drinking Water Ordinance standards with regard to contents and hygiene. This high quality service water is then supplied to the households on the estate via a separate service water network which is laid parallel to the drinking water supply. This service water is suitable for personal hygiene requirements, washing machines and dishwashers, flushing toilets and irrigating gardens. Since the service water has a very low degree of water hardness, the demand for cleaning agents and detergents is correspondingly reduced. When heating this water, there is no need for additional descaling agents.

Rainwater storage tank :



#### Sewage system

A vacuum sewage system is being installed to collect domestic wastewater on the DEUS 21 development area. The building owner has the option to either directly install this system in his house or connect the house to a subterranean transmission station in the conventional way. If the vacuum system is installed in the building, vacuum toilets can be used in bathrooms. These toilets save 80-90 % of the amount of flushing water used by conventional toilets.

#### Biogenic kitchen waste

Since the anaerobic wastewater treatment process can process biological kitchen waste alongside domestic wastewater, some of the houses are equipped with a food waste or garbage disposer (grinder, macerator) to grind kitchen waste. The ground kitchen waste is then discharged to the vacuum sewer system treatment. The joint treatment of wastewater and kitchen waste has two advantages: (1) in the warm season, the kitchen waste in rubbish bins does not emit unpleasant odours or cause hygienic problems, and (2) due to its relatively high content of fat, oil, grease and other organic compounds, kitchen waste considerably increases the biogas yield if co-treated anaerobically with the residential wastewater.



### Wastewater Treatment

The wastewater treatment plant is able to convert the wastewater components into biogas and the nutrients nitrogen and phosphorous into utilisable fertiliser salt. The biogas is used to supply the plant with heat. The wastewater treatment process is designed in such a way that the amount of sewage sludge is very small. It consists of a liquid separation, a two stage anaerobic treatment of solid and liquid phase with special rotating disk filters for the membrane filtration and MAP precipitation and ammonia stripping for nutrient recovery.

## 6. PLANNING AND BUDGET

The project began already before 2004 with preliminary plannings. Now most of the plots are used and the new concept is implemented, but the optimisation of the concept is still ongoing. The project was funded by the German Federal Ministry for Education and Research (BMBF), especially the development and the implementation of the innovative technologies and the accompanying socio-economic research.

*„Water House“: building with the equipment for vacuum system, treatment of rainwater to standards of drinking water ordinance, treatment of the wastewater of the residential area*



## 7. PROBLEMS, DIFFICULTIES MET

When implementing such a new water infrastructure system with interactions to a lot of different stakeholders it is very important to integrate all the different stakeholders and also especially the users themselves. It is necessary to inform all of them very early and to illustrate them the consequences of the new concept. Adequate communication is therefore prerequisite for such projects. On the technical tasks of the project there are still some components to improve or optimize (e.g. rotating disk filters).



## 8. RESULTS TO DATE / LESSONS LEARNT

Drastic changes in the framework conditions of our water infrastructure systems can already be perceived: climate change leads to changes in quantities of precipitation and in rainfall distribution, demographic change (for example a decrease in Germany, but a strong increase in megacities) will lead to clear changes in the number of users of such systems, and new ecological requirements, e.g. in terms of rainwater management or removal of additional pollutants will be introduced sooner or later. Therefore it is necessary to develop and implement innovative and sustainable water infrastructure systems with high flexibility. The innovative DEUS 21-concept is especially promising for areas with no former type of water infrastructure or for smaller communities in agricultural regions because anaerobically treated wastewater can be used for irrigation and fertilization. Another advantage is that nutrients can be recycled from wastewater, which can itself be re-used. As energy is also fed back, relatively small-scale material cycles can be set up profitably

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MARSEILLE, FRANCE '12

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