Research on WASH sector, Environment and Water Resources in the Central Rift Valley of Ethiopia

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Introduction

During 2008 Intermón Oxfam (IO) and Grup de Recerca en Cooperació i Desenvolupament Humà (GRECDH, Research Group on Cooperation and Human Development) met in Ethiopia as both of them engage in researching for effective natural resources management. After some meetings and joint observations, they found out that there were common interests between them, which allowed starting collaboration. Both institutions, IO and GRECDH, were interested on contributing to improve quality and quantity of information regarding the water resources, water supply, water management and environmental governance in the Ethiopia Central Rift Valley (CRV), in order to facilitate an integrated assessment on water and environment, which may help on improving water and other natural resources planning on the area.

Grup de Recerca en Cooperació i Desenvolupament Humà

The Grup de Recerca en Cooperació i Desenvolupament Humà is a multidisciplinary research group at Universitat Politècnica de Catalunya, formed by researchers from different schools (namely Industrial Engineering and Civil Engineering Schools) and different departments. The main objectives of the research group are:

- To reach transferable results aiming to facilitate modernization and improvement of the quality of life in developing countries, through applied research, technological development and innovation, in appropriate technologies for human development.

- To facilitate the economic, social and capacity development in communities of countries and areas with lower resources, by means of transference of knowledge and technologies, in collaboration with other actors within the field of Development Cooperation and Humanitarian Aid.

Among the research issues, it works on water and sanitation, aiming to obtain transferable results which may facilitate both, safe and sustained access to water and sanitation, and protection and a proper management of water resources.

Intermón Oxfam (Oxfam Spain)

Intermón Oxfam (IO) is a Spanish based international nongovernmental organization (NGO) which aims to eradicate poverty and injustice and to ensure that all human beings can fully exercise their rights and enjoy a dignified life. It aims to ensure this through fostering economic justice, the demand of quality essential services, taking a rights approach in humanitarian crises, propelling women's rights and promoting a global citizenship.

IO has been working in the Ethiopian Central Rift Valley for several years in different working lines. Two of them are the *Water, Sanitation and Hygiene Promotion (WASH) Programme* and the *Livelihood Programme* which take planning and natural resources management as their integral parts.

Ethiopia and the CRV

Ethiopia is the second most populated country in Africa with over 73.9 million people (Population Census Commission. F.D.R. Ethiopia, 2008). Its 1,100,000 km^2 ranks Ethiopia as the 10th largest African country, and the country is in the 171st position out of 182 in the Human Development Index ranking (PNUD, 2009).

Agriculture is the backbone of the Ethiopian economy, providing 43.8% of the GDP (13.2% from industry and 43% from services), being also the sector which employs most of the labour force: 85%. Main export crop is coffee, though others such as qat, teff or cut flowers are also important for the economy of Ethiopia. Ethiopia is one of the poorest countries in the world, and although its high growing rate (8%), still the 38.7% of its population lives below poverty line (Central Intelligence Agency, 2009).

Although irrigation is growing all over the country, still droughts have a strong impact on the economic growth. The spatial and temporal variability of water resources limits development and constrains management and an equitable distribution.

Ethiopian Central Rift Valley

The Ethiopian Central Rift Valley (CRV) is part of the East African Rift, an active continental rift zone, which goes along East Africa from the Red Sea to Mozambique. The CRV is situated in the administrative regions of Oromia and the Southern Nations Nationalities and Peoples Region (SNNPR), and covers an area of approximately 10,000 km^2. The area encompasses a chain of four large lakes (Ziway, Langano, Abyata and Shala) and streams that are spatially and temporally strongly interlinked (see fig. 1).

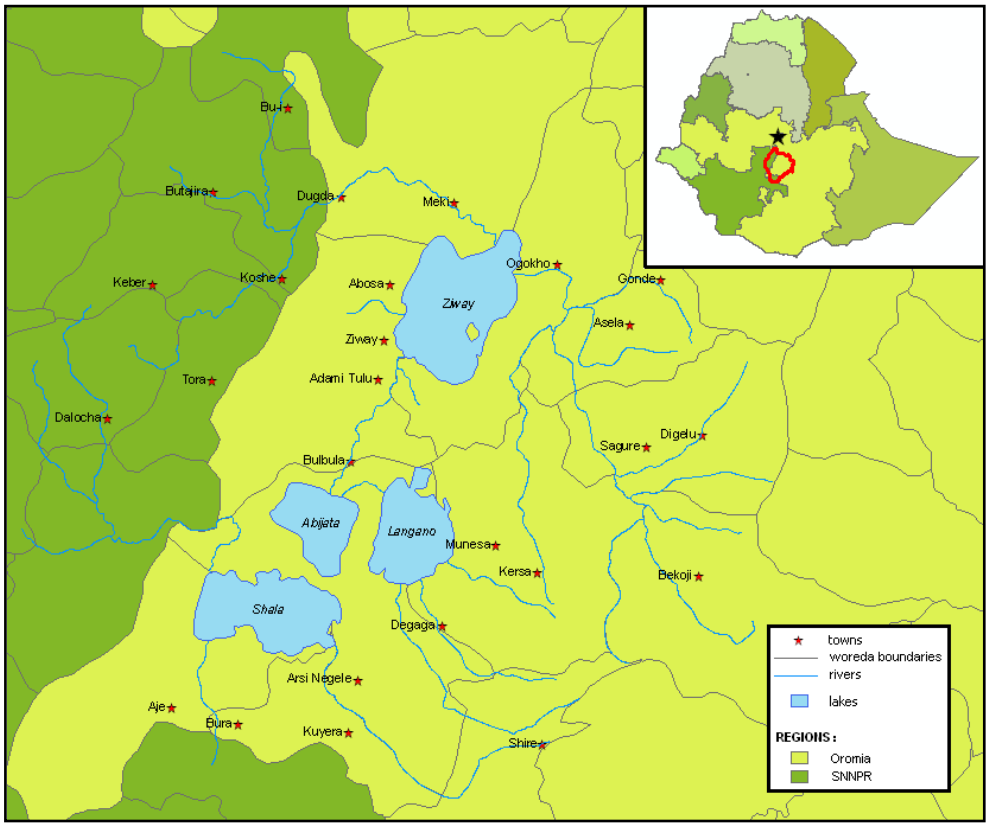

Fig 1. Location map of the Central Rift Valley.

The Rift Valley is one of the environmentally very vulnerable areas in Ethiopia (Ayenew, 2007, Jansen et al., 2007). The lakes are highly productive, harbouring an indigenous population of edible fish and support a wide variety of other aquatic and wild life. They are globally significant freshwater ecosystems containing important areas of both terrestrial and aquatic biological diversity, and most are becoming degraded as a result of human activities (Lake Ziway and their influent rivers are used for irrigation, flower industry, soda abstraction, fish farming, domestic use and recreation) (Ayenew, 2007). Being a closed basin, relatively small intervention in land and water resources can have far reaching consequences for ecosystems, goods and services, and potentially undermine the sustainability use of the area.

In 2007, population living in the Central Rift Valley Basin was around 1.9 million people, among them 1,600,000 were living on rural areas (Population Census Commission. F.D.R. Ethiopia, 2008), but projections of the population on 2035 for the basin range inbetween 4.0 and 4.8 million people, from whom in between 3.1 and 3.7 million will be living in rural areas.

Agriculture production and its related activities is the main pillar that sustains the Central Rift Valley economy. According to the Rift Valley Lakes Basin Integrated Resources Development Master Plan Study Project (Halcrow Group Limited and Generation Integrated Rural Development Consultants, 2007), it is estimated that about 67% of GDP is on the agricultural sector (i.e. crops, livestock, fisheries and forestry) while industry and service sectors account for 10% and 24% respectively. The regional GDP per capita is about 910 Birr per capita (or 105US$ using 2005 exchange rate), which is a low GDP per capita even compared to Ethiopian standards.

A household survey done by the Master Plan consultants has shown that main sources of income of the population are both crop production and livestock products, as it can be seen in table 1.

Table 1. Main and secondary source of income according to a household survey done in the Ethiopian Rift Valley. Source: (Halcrow Group Limited and Generation Integrated Rural Development Consultants, 2007)

Sources of income	Main source of income	Secondary source of income
Crop production	92.31%	3.98%
Livestock products	1.67%	71.20%
Forest trade	2.41%	3.15%
Petty trade	0.09%	6.02%
Off-farming employment	0.93%	10.65%
Others, if any	2.13%	2.22%
No answer	0.46%	2.78%

Low productivity on the crop production, as also the little size of the plots run by farmers (the average is around 0.85 ha per farmer), has conducted farming to be subsistence based. Livestock is part of the farming system in the highland areas, where animals are grown for meat and milk production and also used as draft animals, being an important contribution to the income of households. In the drier southern lowlands of the Rift Valley, livestock production is based on semi-nomadic pastoral systems and is seen as the main source of wealth. Livestock trading and retail trade in consumer goods are the most common alternative sources of income, as also additional income is obtained by charcoal production, although it is considered an illegal practice. Other sources of employment include government, NGOs and cooperatives.

Development

According to Ethiopian Water Resources Management Policy established by the Ministry of Water Resources in 1999, the core policy principles are: considering water as an economic good; to promote the involvement of all stakeholders to improve efficiency; to devolve ownership and management autonomy to the lowest possible level; to establish proper financing, water pricing and cost recovery policies; to develop an integrated planning for water supply, sanitation and hygiene; and to integrate environmental and natural resources management into water resources administration (Raventós Vilalta, 2010). Different policies and laws have been announced regarding water management and environmental governance, including the Water Resources Management Proclamation (2000), an Ethiopian Water Sector Strategy (2001), a Water Sector Development Program (2002) or Environmental Impact Assessment (EIA) Guidelines (2004).

Through the present collaboration between IO and GRECDH a survey among different stakeholders has been carried out. Main aim of the survey was to understand the formal and informal rules on water management, implementation progress of the policies, and the coordination among stakeholders as also to verify the level of awareness of environmental and water problems. It included different levels of administration (Federal, Regional and District/Woreda), NGOs, Community Base Organizations and private investors. The survey has aroused a lack of further development of the policies and laws, as also some inadequacies between law and reality due to unawareness of law and policy statements and the lack of financial resources and qualified staff.

However, in order to achieve a global good water governance, on the 2002 World Summit on Sustainable Development which took place in Johannesburg it was set that all countries should develop Integrated Water Resources Management (IWRM) plans (United Nations, 2002). IWRM can be defined as a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership, 2000). Lately a basin authority for the basin has started to be put in place in order to start working as the international agreement established. This may help on a better coordination of all stakeholders in order to achieve sustainable development.

Assuming that main problems water, land and environmental management may face are to improve citizens wealth ensuring an equitable access to water and to avoid and revert the already existing environmental problems; and having in mind the capacities of both organizations (IO and GRECDH), main working lines established have been focused on equity on the access to water supply and sanitation, on identifying major environmental problems and modelling the superficial hydrology of the basin. Next, each of these lines will be presented.

Access to water supply and sanitation

On 2008, just 38% of Ethiopian citizens had an improved access to water supply, while the 12% had access to improved sanitation, and data from rural population is even more impressive, since just the 26% of the citizens has access to improved water supply and 8% has access to improved sanitation (WHO/UNICEF, 2010). The Joint Monitoring Programme (WHO/UNICEF, 2000) established “improved” and “not improved” water supplies based on the technologies used, as it can be seen in table 2. On the other hand, “improved” and “not improved” sanitation facilities classification is based on the hygienic separation of human faeces from human contact as also on its private use (but not shared or public) as can be seen on the technologies in table 3 (WHO/UNICEF, 2010).

In order to improve efficiency and support the decision making process, there is the need to have accessible, accurate and reliable which is routinely collected and updated. During the project, the development of a methodology which may help on improving data collection and analysis has been undertaken through a case study at Bora District, in the CRV.

Table 2. Definition of "improved" and "unimproved" water supplies. Source: (WHO/UNICEF, 2000)

"Improved"	"Unimproved"
Piped water into dwelling, plot or yard	Unprotected dug well
Piped water into neighbor's plot	Unprotected spring
Public tap/standpipe	Small cart with tank/drum
Tubewell / borehole	Tanker truck
Protected dug well	Surface water
Protected spring	Bottled water *
Rainwater	

* Considered as "unimproved" because of concerns about the quantity of water supplied, not because of concerns over the water quality.

Table 3. "Improved" and "unimproved" sanitation facilities.

"Improved"	"Unimproved"
Flush or pour-flush to:	Flush or pour-flush to elsewhere *
- piped sewer system	Pit latrine without slab or open pit
- septic tank	Bucket
- pit latrine	Hanging toilet or hanging latrine
Ventilated improved pit latrine (VIP)	No facilities or bush or field
Pit latrine with slab	
Composting toilet	Public or shared sanitation facilities

* Excreta are flushed to the street, plot, open sewer, a ditch, a drainage way or other location

Among different methodologies developed to collect data, one which allows displaying it on a user-friendly format is the Water Point Mapping (WPM). The WPM can be defined as an "exercise whereby the geographical positions of all improved water points in an area are gathered in addition to management, technical and demographical information. This information is collected using GPS and a questionnaire located at each water point. The data is entered into a geographical information system and then correlated with available demographic, administrative, and physical data. The information is displayed using digital maps" (WaterAid and ODI, 2005). Moreover, the WPM can be improved through the collection of data of water quality parameters (measured with a portable water testing kit), and the assessment of the seasonality of the water points, variation known as enhanced Water Point Mapping (eWPM) (Jiménez and Pérez-Foguet, 2011).

Regarding this methodology, during the survey carried out at Bora District, data collected on a WPM included, among others: (i) GPS position; (ii) reliability and seasonality of supply; (iii) demand and water use; (iv) operational status; (v) ownership and management system; (vi) maintenance; (vii) water quality parameters; and (viii) assessing seasonality of the water points.

On the other hand, there is no doubt that both sanitation and hygiene have also a real impact on household health (Cairncross, 1990), arising the importance to get also information on the use of sanitation facilities as also on the hygiene practices. Then, to have a more complete diagnostic for decision-makers, an integrated water, sanitation and hygiene approach for data collection may be useful.

In the present project this integral approach was used. Using the WPM as a starting point to obtain information from all available water points, clusters of households were randomly selected in the surrounding areas. Aimed at obtaining a statistically representative sample of households, 200 surveys per municipality (kebele) were required (amounting more than 3.600 surveys for the whole district). Information collected on the surveys included, among others:

- Water: (i) type of main drinking-water source, (ii) time to fetch water, (iii) water consumption, (iv) water uses; (v) user satisfaction on service level...
- Sanitation: (i) access to sanitation infrastructure; (ii) use of infrastructure, (iii) conditions of sanitation infrastructure (if this hygienically separates human excreta from human contact, privacy, insects, smell, cleanliness...).
- Hygiene: (i) hand washing behaviour, (ii) hygiene awareness, (iii) water quality inspection...

Moreover, some data on socio-economic aspects was collected in order to study the relationship between wealth and different components of the survey.

Data collected in the household survey can later be combined with the data recorded at water point level (Giné Garriga and Pérez-Foguet, 2011).

Among much more information results aroused some facts which are here presented as exemplary results:

(a) While just three of the thirty-three water points used by the population are not improved water points, only the 64% of the population is using an improved water point to fetch water. Regarding sanitation, the 42.4 of the population is using an improved facility (see fig. 2)

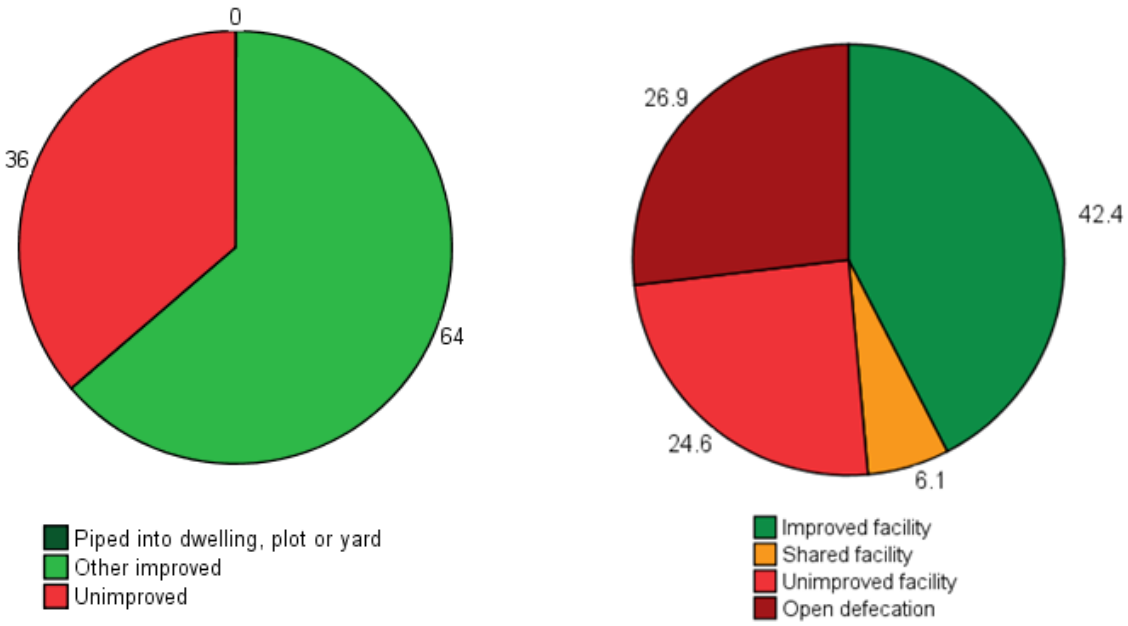

Fig. 2. Use of improved and not improved water supply facilities and use of sanitation facilities used at Bora District.

(b) Meanwhile it appears that there is no relationship between the use of improved and unimproved water points according to the level of wealth, data shows a relationship between wealth and the practice of open defecation (see fig. 3).

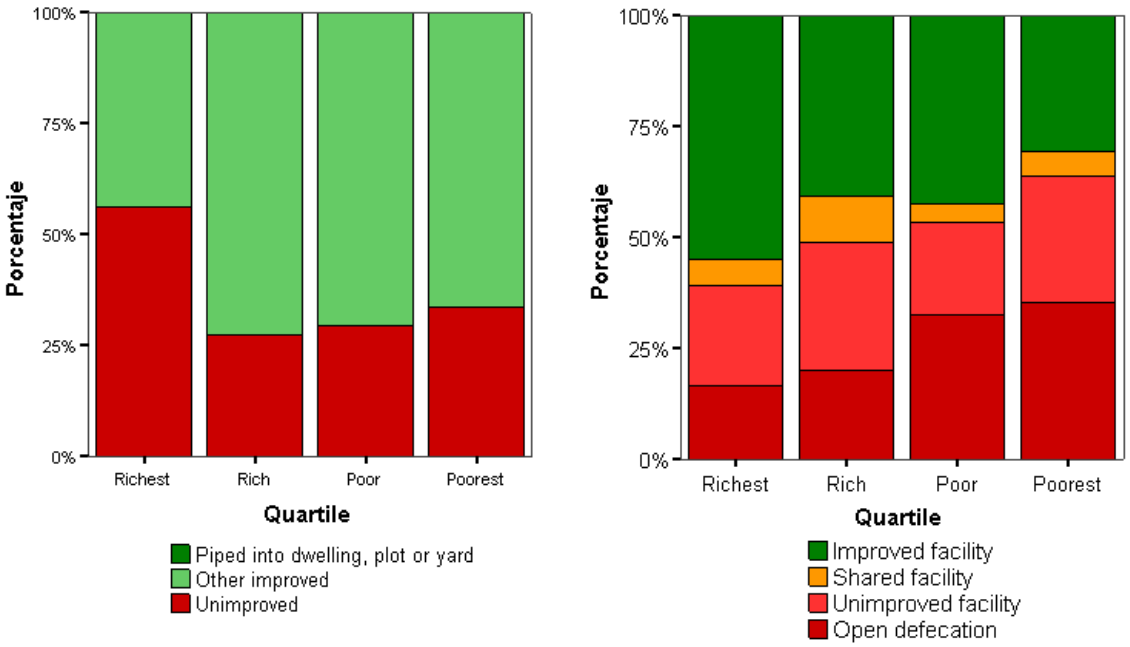

Fig.3 Relation between the use of water supply facility and wealth, as also relation between the use of sanitation facility and wealth at Bora District.

Environmental Problems

One of the aspects studied during the collaboration was to assess main environmental problems existing on the basin, either through the surveys undertaken as also through literature review and a study undertaken by IO together with Ambo University on water quality. Main problems that aroused are presented next.

Water quality

Poor water quality is one of the environmental problems that arise on the CRV basin. Its low quality is produced either by anthropogenic and non-anthropogenic causes. Regarding the non-anthropogenic causes, the most important one is the high levels of fluoride present in water, which can be found all over the basin (Research-inspired Policy and Practice Learning in Ethiopia and the Nile region, 2008). Moreover, lakes have a high salinity concentration due to the large amount of water being evaporated. On the other hand, anthropogenic contamination of water in the basin may appear from pesticides and other agrochemicals used by large scale and small scale agricultural production.

Water scarcity

Massive water abstraction for different uses (domestic, agricultural, livestock and industrial) with little regulation and control is being detrimental to downstream users, who are facing severe difficulties due to lack of water. Interviews show that inhabitants of the area (affected people), public institutions and NGOs are already aware about water scarcity, but it appears to be that not all of them perceive which is the real cause, as they blame a reduction of rainfall while during the last 50 years there has been no substantial reduction of the rainfall (Ayenew, 2004).

Lakes level change

Lake Abyata has a very flat bed causing great changes in his area when lake level changes, which has occurred due to the increase on water pressure in the upper stream. But not only area changes can be

perceived: over the past decades its level has changed drastically, being reduced to almost the 50% of its previous depth (Ayenew, 2007).

Deforestation

Deforestation is a problem that affects most of the country. Between 150,000 and 200,000 ha of forest disappear every year in Ethiopia, mainly to get wood as fuel, for building and because of the need of new agricultural land (Ayenew, 2007), and the CRV it is not alien to this problem. This phenomenon has important consequences both locally and nationally. Forests are provider of biodiversity, not only understood as a set of plant species, but also as providers of many ecosystems and natural resources (Gatzweiler et al., 2007).

Land degradation

The main cause of land degradation is on the poor agricultural practices (Sissay, 2003). Increasing irrigation farms using salty water, combined with furrow irrigation system (most common in the area), is causing the salinization of the soil. In addition, use of pesticides and other agrochemicals in excess aggravates this phenomenon. This problem is causing abandonment of fields where is not possible to get good production (Shimelis, 2008) as also increasing deforestation as farmers deforest new areas to get new farms (Sissay, 2003).

Biodiversity degradation

Deforestation and loss of vegetation cover in many areas of the CRV causes that sediment and nutrients are washed away by surface runoff into rivers and finally reaching the terminal lakes. This causes an increase in nutrients that favours eutrophication, a process by which an excessive development of bacteria (promoted by presence of large amount of nutrients) significantly reduces oxygen concentration of water. This phenomena may kill fishes and other underwater organisms, and these effects can be seen in Lake Abyata (Ayenew, 2007). In addition, the disappearance of forests of acacia for charcoal production causes a reduction of the habitat and food source of migratory birds (Shimelis, 2008).

The region exhibits rich biodiversity resources, including plant, invertebrate and vertebrate species, being especially known for its diverse bird species. This rich biodiversity occurs both within and outside areas protected for wildlife conservation, where there are both resident and migratory bird species, e.g. lake Langano serves as a stopover for such globally threatened bird species as lesser kestrel, pallid harrier and lesser flamingos, as well as pelicans, plovers, terns and eagles (Oromia Environmental Protection Office, 2005).

Climate change

Climate change is a global phenomenon manifested since last century due to emissions of greenhouse gases. Its effects on climate may appear on an increase of climate variability, changing periods of rain and type of precipitation, as also on a rise of temperatures (Halcrow Group Limited and Generation Integrated Rural Development Consultants, 2007). Scenarios developed for the years 2001-2099 showed that both temperature and precipitation are likely to increase from the 1981-2000 level. Despite the increasing trend of both climatic variables, the increase in precipitation seems to be obscured by increases in temperature. Hence, the total average annual inflow volume into Lake Ziway might decline significantly and be insufficient to meet future demands for water of the ever increasing population (Zeray et al., 2006).

Hydrological modeling

Aimed at achieving an efficient use of available water, information on water dynamics at basin level is needed. The most common approach is through the use of hydrological models, which may help to find out how water is moving along the watershed. This may provide an accurate assessment on the distribution of water resources along the basin, may help on the study of present impacts of water uses and may allow displaying future scenarios. Consequently, it may facilitate decision making related to land and water management (Codony Gisbert, 2010).

Due to the available data of the basin, superficial hydrology modelling has started to be done using the code ArcSWAT. The software includes the SWAT (Soil and Water Assessment Tool, Arnold et al., 1998) model developed for the USDA Agricultural Research Service into ArcGIS (ESRI®). SWAT is developed to assess the impact of land management practices on large complex watersheds with varying soils, land use and management conditions over long periods of time. SWAT is physically based; although it can study complex processes is computationally efficient (Neitsch et al., 2005).

Data input includes, land use, type of soils, climate data and river flow. Surface elevation was obtained from a 90mx90m grid DEM provided by the USGS from SRTM data. Ten different types of land use (see table 4) based on satellite images (Jansen et al., 2007) as also nine different type of soils have been considered.

Table 4. Land use coverage at the Central Rift Valley. Source: (Jansen et al., 2007)

LAND USE	COVERAGE
Large irrigated farm	0.5%
Swamp and wetland	0.9%
Other wet areas (incl. irrigated lands)	2.4%
Open water	7.3%
Forest	3.1%
Degraded savannah	1.3%
Bare land	1.1%
Intensively cultivated	38.1%
Mixed cultivated / acacia	37.4%
Open woodland	7.8%

Meteorological data set includes daily precipitation values for the 1987-2004 period from seven different meteorological stations, temperature data from the same period for two different stations and relative humidity and wind speed temperature from one station for the period 1996-2005.

Once all data is prepared for the programme use, there is the need to find out the optimum values for the different parameters that the model uses, process which is commonly named calibration of the model. First of all a sensitivity analysis of the different parameters shall be done in order to analyse which parameters of the model give bigger variations on the simulated outputs. This has been done using the Latin Hypercube-One-factor-At-a-Time (LH-OAT) (Green and van Griensven, 2008). After this analysis, the parameters identified will be used for the calibration, aiming to minimize the differences between the measured streamflow and the simulated streamflow, using as function to be minimized (or objective function) the sum of the squared residuals (SSQ):

$$SSQ = \sum_{i=1,n} \left[x_{i,measured} - x_{i,simulated} \right]^2 \qquad \text{Eq. 1}$$

This process is done using the Parameter Solutions Method (Parasol) (van Griensven et al., 2006), which conducts not only calibration - through the Shuffled complex evolution algorithm (Duan et al., 1994) - but also an uncertainty analysis. Once parameters have been calibrated, the goodness of the model needs to be validated comparing simulated results of the streamflow with measured streamflow.

According to the CRV available data, calibration period used ranges from the 01/01/1990 until 12/31/1998 meanwhile the validation period was from 01/01/1999 until 12/31/2004.

As expressed before, once the model has been properly calibrated and validated, it may help on calculating impacts of water resources management, both economical and environmental, as also can be a tool to simulate future scenarios.

Conclusions

These types of collaborations between a Development NGO and a research group at University carry some drawbacks to both organizations. Tempos of both organizations may be sometimes different, which may cause little disruptions on both sides of the partnership. Moreover research field trips management by University and field work management of students by the NGO are not common tasks for both organizations. Lastly, as those kinds of project collaborations are still not much common, finding a donor is not such an easy task. Fortunately, some donors understood the advantages of such collaboration, and funding of the project was mainly given by the Col·legi d'Enginyers de Camins, Canals i Ports de Catalunya (CECCPC, Civil Engineering Association in Catalonia), but also the Agència Catalana de Cooperació pel Desenvolupament (ACCD, Catalan Agency for Development Cooperation) and the Centre de Cooperació per al Desenvolupament – UPC (CCD-UPC, Development Cooperation Center at UPC) contributed to its implementation.

But overall, collaboration is seen as advantageous for and by both partners. For the academic community, knowledge is being improved through the research carried out. Already three different MSc. Theses have aroused: one related to the real state of water resources management in the basin, another on the environmental governance also on the CRV and the last one on the WASH survey carried out at the Bora District. Moreover posters and communications have been already accepted in four different congresses, three of them being international congresses. Although the first phase of the project has already finished, future publications are expected to come out on the forthcoming months. Moreover, it will help IO to strengthening of the ongoing programs and development of new programs in the area. In addition such findings are also spread to other stakeholders working at the basin to support local institutional capacities.

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