PROJECT FINAL REPORT

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Name of the scientific representative of the project's Coordinator[1], Title and Organisation:

Dr. Markus Starkl

University of Natural Resources and Life Sciences, Vienna

Tel: +43 1 47654 5057

Fax: + 43 1 47654

E-mail: markus.starkl@boku.ac.at

Project website address: www.project-vivace.net

[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.

Final publishable summary report

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EXECUTIVE SUMMARY

Latin American mega-cities face the increasingly difficult task of providing water services for its growing peri-urban areas, assuring a safe provision of drinking water, a safe handling of wastewater, and an adequate solid waste collection and processing. Conventional ideas on water supply, sanitation and solid waste management are not always able to cope with this task. Further, increasing pressures on resources require solutions that aim at resource conservation and recovery. With increasing size of cities, it becomes difficult to keep extending the existing centralised water supply lines and centralised collection of all waste and wastewater. Novel and decentralised concepts are needed to analyse and improve the situation in those areas, looking at them from a holistic point of view and searching for new opportunities, including possibilities for nutrients and energy recovery and reuse.

Against this background VIVACE explored the potential and constraints of decentralised water and waste systems that allow for reuse and recycling of water, nutrients and energy. For this purpose VIVACE studied two peri-urban areas in two of the largest cities of Latin America: Xochimilco in Mexico City and Tigre Island in Buenos Aires. In each case study the following work was conducted:

- A base line study to capture the existing situation and challenges
- Participatory planning and scenario analysis in order to understand the perceptions and visions of the concerned users and stakeholders with respect to water and waste management and to compare different scenarios
- A technical feasibility study to identify both conventional centralised and innovative decentralised solutions for water and waste management and to assess their technical feasibility
- An economic impact study to identify the contribution of better water and waste services on the economic development of the case study areas
- An integrated assessment to identify the economic, environmental and social impact and risks of all examined technically feasible systems
- Policy workshops to present the results of the study to stakeholder's and policy makers and to discuss with them the implications on existing policies and to elaborate policy recommendations

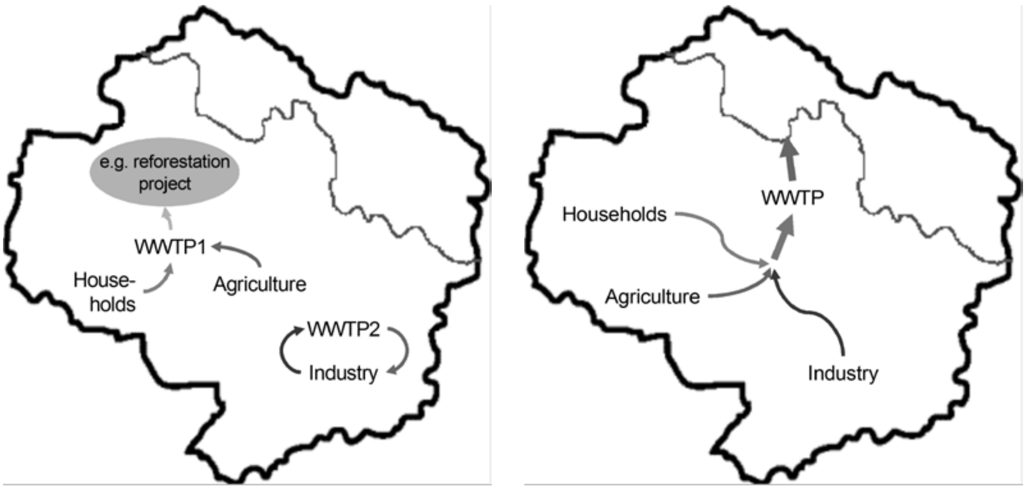
VIVACE has shown that a management alternative that aims at maximisation of resource conservation may not cost less than a conventional management approach. Moreover, decentralized technologies aiming at resource recovery would require users to accept more responsibilities. Focus groups have shown that users would be prepared to take those responsibilities. However, their overall preference would still be towards centralised services. Therefore there is the risk that in the long run users would no longer be willing to operate such systems themselves. Hence it needs to be explored, if professional organisations can take care of the operation and management, which will cause higher costs. Finally, VIVACE confirmed that the alternative technologies are less compatible with the existing institutional system (regulations, laws, capacity of existing institutions). Therefore, substantial investment need to be provided for training and awareness raising activities and existing regulations and laws may impede the implementation of alternative technologies.

In conclusion, management alternatives aiming at conservation, reuse and recycling of resources are very beneficial to the environment. However, to ensure their overall sustainability they need to be supplemented with a policy and institutional framework that is clearly supportive of such alternatives. Thereby, pilot projects are a means to trigger social learning processes that may facilitate a transition from the current management approach to a more resource friendly management alternatives in peri-urban areas.

PROJECT CONTEXT AND OBJECTIVES

VIVACE analyses the potential for implementing innovative concepts integrating water management (focusing on water supply and wastewater management), waste management (focusing on organic wastes), and agricultural management (focusing on irrigation and fertilizing). Considered points of integration of these sectors are water reuse, nutrient recycling, and energy recovery. The spatial focus of VIVACE is on peri-urban areas of Latin American mega-cities. These are rapidly developing urban or small town areas, together with their rural/natural surroundings. Thereby, VIVACE works in two case studies: San Gregorio in Xochimilco in Mexico City, and Tigre in Buenos Aires. The systems boundaries are set on a case specific basis in such a way that the mutual impacts of water extraction and wastewater/waste disposal can be assessed. VIVACE analyses existing shortcomings for natural resources management and evaluates the potential of proposed innovative concepts, considering also economic development.

Instead of designing each sector (water supply, wastewater, solid waste) separately, VIVACE studies concepts that combine the in- and outflows of the different sectors, reusing water and (where possible) other liberated resources. This approach is illustrated in Figure 1. Integration of these sectors was studied in terms of water reuse, nutrient recycling and energy recovery. Thereby, wastewater is seen as a potential water, nutrient and energy source, and it is evaluated for its suitability as a water source for a specific use, such as agriculture, non-potable domestic purposes or forest irrigation. This links water management to organic solid waste management and agricultural water management.



(**a**) (**b**)

Figure 1: (a) resource oriented way of thinking on a regional scale. WWTP1 and WWTP2 can constitute completely different technologies (WWTP = Wastewater Treatment Plant). And (b) Traditional way of thinking about wastewater treatment

However, such systems may cause new challenges to water management, such as the loss in economy of scales due to decentralisation. There arise also possible new risks, in particular if potentially infectious substrates need to be handled (e.g. faecal waste). Further, users may prefer conventional, centralised solutions.

Against this background, VIVACE is based on two conceptual pillars: innovative technical concepts for vital and viable services (the attribute “innovative” relates not so much to technical innovation but to the concept of reuse and recycling, as described above) and integrated analytical approaches and decision support tools.
Integrated analytical approaches for decision support and strategic planning are applied, with particular focus on tools for integrated and participatory assessment. Traditionally costs are decisive for selecting and implementing technical solutions. However, research has shown that for overall sustainability several other aspects have to be considered. VIVACE assessed the technical concepts along three dimensions of sustainability: Economy, Society, Economy

As a supporting action, VIVACE pursued the following overall S&T objectives:

Exploring the existing potential and constraints for natural resource management related to coping with the often contradictory challenge of integrated resource planning and thereby contributing to the implementation of the Framework Programmes and the preparation of future Community research and technological development policy

- Interact with a wide range of societal actors and thereby stimulate, encourage and facilitate the participation of SMEs, civil society organisations and their networks, small research teams and newly developed or remote research centres in the activities of the thematic areas of the Cooperation programme

Instrumental to these overall S&T objectives were the following specific S&T objectives of VIVACE:

1. *Learning from the rich experiences stemming from past and ongoing projects*

This objective allowed VIVACE to utilize the wide knowledge and experience available in the target countries. Many endeavours have been initiated up to now in order to tackle the several problems faced by natural resource management. VIVACE aimed at capturing those experiences in the partner countries.

2. *Identification of feasible innovative concepts for natural resource management related to the project's sectoral and spatial scope*

This objective aimed at the identification of innovative concepts for natural resource management related to the project's sectoral and spatial scope. VIVACE carried out an analysis of the technical feasibility of these concepts in the case studies.

3. *Development and application of integrated analytical approaches and methods for decision support and strategic planning*

Based on the challenges and potential conflicts for integrated resource planning related to VIVACE's scope, integrated analytical approaches for decision support and strategic planning were developed and tested. In particular ecological, economic and social impact assessment tools and tools catering for an integrated and participatory assessment of these aspects were considered, building up on the wide experience with such tools (e.g. multi-criteria tools). This included:

- Participatory approaches
- Scenario building methods
- Integrated assessment

This objective further aimed at developing and testing integrated analytical approaches and methods, which build up on the experiences made with such approaches up to now in the targeted countries and which can be used to solve the specific problems identified in view of options developed under objective 2 in the case study situation.

4. *Preparing and supporting the case study based work related to objectives 2 and 3*

In the two case studies the activities related to objectives 2 and 3 were carried out. Objective 4 aimed at preparing and supporting these case study based activities through the following tasks:

- Preparation of outline base line studies
- Analysis of the impact of existing resource management (within the sector mentioned above) on the economic development in the region
- Prepare outline stakeholder analysis and support stakeholder interactions

5. *Synthesis of lessons learned, elaboration of policy recommendations, and facilitation of the uptake and integration of the project's results*

This objective aimed at

- developing multi-stakeholders discussions for learning across disciplines and scale boundaries
- summarising lessons learned from other project activities and elaborate policy recommendations where applicable
- disseminating the project results among a wide audience

Thereby, VIVACE identified together with various stakeholders the existing shortcomings for natural resources management. Interested stakeholders also took part in developing innovative concepts. Integrated analytical approaches for decision support and strategic planning used criteria, developed together with stakeholders, to assess these concepts. These assessments discussed with stakeholders to develop policy recommendations. At the level of Latin American decision-maker (administration, policy, planning), the results and recommendations of VIVACE were disseminated through workshops with stakeholders and through publications in Latin America. At the international level, dissemination was through contributions to international conferences and through publications in peer-reviewed research journals. These activities are continued.

The work performed was conducted by the following partners:

- University of Natural Resources and applied Life Sciences Vienna, Austria
- Lettinga Associated Foundation, Netherlands
- International Institute for Environment and Development- America Latina, Argentina
- Instituto Nacional del Agua, Argentina
- Instituto Mexicano de Tecnologia del Agua, Mexico
- Centre for environmental management and decision support, Austria

MAIN S&T RESULTS/FOREGROUNDS

VIVACE is a supporting action and as such has not aimed at developing new foregrounds. Rather it aimed at demonstrating and disseminating state of the art knowledge with respect to the scope of VIVACE to relevant stakeholders in Latin America. With this respect VIVACE has achieved the following main S&T results:

Application of an innovative participatory planning approach

Participatory planning is considered an important aspect for achieving sustainable water services. In this project an innovative approach using scenario building methodology was applied. From the wide range of available methods for scenario building, in this project we were in particular interested in those which allow the users to participate in shaping the development of their region. An example for such a method is the Future Workshop (FW) method.

The scenario workshop aimed at the identification of different options for future regional development. Building on the outcomes of the scenario workshops, a workshop for participatory planning was conducted. This workshop focused more on the technical aspects with respect to water, wastewater and solid waste management. It encompassed two main phases: the existing environmental problems in the area were discussed; and the participants identified possible solutions and highlighted the main conflicts and barriers that need to be overcome to implement those solutions.

The results of the participatory planning workshop and the resulting concept scenarios are presented in the following sections:

Mexico

A group of social stakeholders living or working in Xochimilco was invited for a meeting held in Xochimilco. The workshop participants were mainly inhabitants of Xochimilco, who are active in the development of the area. Representatives of the local water supplier, academic institutions active in the area, NGOs and producer groups also participated. This was important because they expressed controversial perceptions of where they live and have different ideas about how the problems in the area could be solved.

The workshop was divided into different sessions. In session 1 the main characteristics of VIVACE were introduced, as well as the projects’ objectives, scope and expected results. Session 2 was a plenary meeting where participants identified the main environmental problems in the area, wrote them individually on small cards and put them on the wall according to thematic area. The thematic scope focused on the areas relevant for VIVACE: water supply, wastewater, agriculture and solid waste. Institutional problems, which could not be assigned to any of the topics, were put around the four themes. For session 3 the audience was split into two groups, one focused on agriculture and solid waste, one on water and wastewater. The groups then proposed potential solutions, highlighting the main conflicts and barriers to overcome. In the last session the ideas and conclusions of were presented and subjected to general discussion.

Figure 2 and Figure 3: Participatory planning workshop in Mexico

During the workshop participants defined the technological problems related to the water supply, wastewater, agriculture and solid waste for peri-urban areas in Xochimilco that they experience or perceive.

With respect to the experienced problems, participants acknowledge the water supply problems, including depletion of the aquifer and poor water supply services. However, the participants have also identified that rainwater harvesting technologies are currently not applied for domestic water supply in the peri-urban areas. In addition, they also state that the water quality, both of the environmental water as well as the domestic water, is often poor. This results in health problems.

The participants perceive the discharge of poorly or untreated wastewater to the channels, streets and environment as severe problem. This results in water pollution, loss of biodiversity and health problems. The performance of the wastewater treatment plants is perceived as being poor, both in terms of quantity and quality.

With respect to agriculture, there is too little water for agricultural purposes and the capacities of the farmers are lacking as well. In addition, the profitability of agriculture in the peri-urban areas is decreasing. The loss of agricultural land and indigenous agricultural practices such as the chinampas is perceived as a problem.

In relation to solid waste management, the absence of solid waste classification, collection and recycling is a problem. Related to this is the lack of awareness about the possibilities for separating and recycling solid waste. The participants also state that the discharge of solid waste to the environment is a major problem, which affects the water supply and agricultural sectors as well.

The solutions proposed by the participants are summarised in Table 1.

Table 1: Solutions proposed by participants

Water supply	Wastewater	Agriculture	Solid waste
• Introduce alternative technologies for the capture and management of water • Creating a system for infiltration for groundwater recharge. • Install water filters to clean water from the channels • Investigate unproven solutions.	• Separating the storm sewer. • Treatment of sewage in wetlands • Filters for grey water treatment • Installation of waterless urinals • Installation of dry toilets	• Cultivation of new products (e.g. dried vegetables) • Preserving traditional cultivation methods • Modernization of agriculture in a sustainable way • Building of a storage facility with appropriate equipment • Reforestation	• Initiation of a separation program and waste collection with community participation

In the next step, the results of the scenario workshop and the participatory planning workshop were combined and concept scenarios were developed. Each concept scenario is related to one of the possible development scenarios and encompasses a set of technologies that is suitable for the development scenario. In addition, a new concept scenario has been created that is related to increased urbanization. Even if that was not preferred by the participants of the scenario workshop it is a very realistic scenario as a recent trend analysis based on GIS data has shown. The identified three concept scenarios are summarized in Table 2.

The results of the scenario building and the participatory planning were combined and then different concept scenarios were developed. A concept scenario encompassed a coherent set of water technologies that are suitable for a different future development scenario (e.g., urbanization or conservation). The concept scenarios were then furnished with a set of suitable technologies.

Table 2: Concept scenarios Mexico

Name of scenario	Key objectives	Characteristics of technical solutions
Local identity	The goal of this scenario is the conservation of local identity which is related to the cultivation of chinampas and the prevention of external influences.	In this concept scenario individual technical solution are preferred over centralized ones to become more independent from Mexico City.
Economic development	The goal of this scenario is economic development with a strong focus on agriculture. In the mountainous areas where no agriculture is practiced, there is a focus on community development.	In this scenario there is a strong emphasis on sanitation systems that allow the reuse of nutrients and the water in the chinampas or in some other areas to improve the agricultural production. In the hilly area, community technologies are the main feature of this scenario.
Centralisation	The main goal is a strong connection to the development of Mexico City and integration into the planned urbanization.	All infrastructure services are centralized as much as possible.

Argentina

The main objective of the workshop "Environmental challenges and innovative approaches to water and waste management on the islands of the Municipality of Tigre“ was to generate a dialogue with relevant stakeholders concerned about the present and future of the islands of Tigre, understand and incorporate their concerns and knowledge (theoretical, practical and methodological), facilitating a common analysis to provide new ideas for the solution of environmental problems related to water and sanitation at different scales (family, school and tourism) within the study area of the project.

A group of social stakeholders (government, civil society organizations, companies and academic institutions) working in the island of the municipality of Tigre was summoned for this meeting held in Tigre.

The workshop presented five different stages, i) Introduction of main VIVACE project´s characteristics, its objectives, scope and expected results; ii) A plenary meeting where participants identified the main environmental problems in the area, iii) Splitting of the audience into two groups where potential solutions were proposed, highlighting the main conflicts and barriers to overcome; proposals of the working groups were presented arriving to a synthesis; iv) in addition, INA and IIED-AL presented their analysis of problems and a preliminary proposal of possible solutions (technological and social), and v) finally, a general discussion and reflection was developed in a plenary session.

The participants discussed first the main problems in the case study area and then developed technical and institutional solutions to those problems.

Overall, the main problems perceived by the participants relate to pollution of the environment that causes health risks as the water sources are polluted with chemicals, toxins and sewage. In addition, agricultural land in the Parana and Lujan Rivers upper basins is polluted by the use of toxic herbicides. Interestingly, the participants mention that the collection methods and rates of the solid waste collection facilities are perceived as a problem. Although the latter are strongly related to the institutional and economic aspects, it shows that there is room for improvement within the current systems.

Table 3 shows the technical solutions proposed by the participants. The main focus here is on an expansion of the centralised drinking water supply network and several low-tech solutions for low-income households. In order to distribute potable water among islanders they propose the development of a water network connecting the various islands (with a cooperative administration system). Presently works are performed in order to construct an aqueduct to intake water from River Paraná de las Palmas and to feed an enhanced continental potable water treatment plant (Dique Luján).Wastewater treatment technologies include septic tanks, cesspools and natural wetlands, which generally need little operation and maintenance and are relatively simple to construct. It should be noted that one participant mentioned the use of dry toilets, or EcoSan, but that this was not supported by the other participants. The participants themselves also proposed the classification and separation of solid wastes, centralised waste storage reservoirs and composting and digestion.

Table 3: Technical solutions proposed by the participants

Water supply	Wastewater	Agriculture	Solid waste
• Centralized drinking water service: Main pipe through Luján River and distribution through cooperatives (local labour). • Connection to a centralized-continental potable-water system and development of an islands supply network • Water solar irradiation • Electro-coagulation (without chemical coagulation)	• Dry toilet • Wetlands • Septic tanks/cesspools • Enforcement of sanitation and wastewater treatment in continental basins	• None	• Garbage classification at origin • Pier garbage reservoirs • Worm-composting • Anaerobic digestion

As for Mexico, the results of the scenario building and the participatory planning were combined and different concept scenarios were developed.

Table 4: Concept scenarios Argentina

Name of scenario	Key objectives	Characteristics of technical solutions
Green Delta	The goal of this scenario is the conservation of the sensitive ecosystems in the Delta.	Natural technologies which support environmental protection and independency of the continental area are favoured. Local water sources are used
Economic Development	The goal of this scenario is economic development with a strong focus on tourism.	Decentralised solutions that cater the needs of the touristic providers (eg. hotels)
Centralisation	The main goal is a strong connection to the development of Buenos Aires and integration into the planned urbanization.	Centralisation of all infrastructure as far as possible

Demonstrating the feasibility of decentralized water and waste technologies

A technical feasibility study was conducted, which aimed at demonstrating the technical feasibility of the identified technologies for each concept scenario. As a detailed feasibility study for the entire case study area was beyond the scope of this study, a smaller area was considered much better to suit for testing the concepts and its technologies. For the selection, some criteria including infrastructure, urbanization, remoteness and socio-economic conditions were applied to ensure the selection is representative for most peri-urban areas in Xochimilco and Islands of Tigre.

The detailed feasibility study was then conducted for each concept scenario in the selected smaller areas. The following tasks were conducted:

1) A detailed survey of the existing infrastructure in the case study area and a household level survey in the selected smaller areas.

2) A detailed technical feasibility study, which included technical design and drawings of the set of technologies within each concept scenario, thus demonstrating their technical feasibility.

Mexico

Regarding the status quo, in Table 5 actual practices pertaining VIVACE's sectoral scope, are presented.

Table 5: Actual practices related to water supply, wastewater, irrigation and solid waste

Water supply			**Wastewater**	**Solid waste**
Domestic use	Human consumption	Irrigation		
• Informal connection • Tanker truck • Collection and transport from nearest well	• Direct use of domestic water • Bottled water • Boiling of domestic water	• Canal water	• Septic pit • Canal discharge • Crack or slope discharge	• Centralized system • Informal landfills • Canal system disposal

The main problems that have been identified in the management of natural resources in the status quo of the case study area are related to:

I. Water supply deficiencies: Service provision obtained by inhabitants through actual practices in the water supply sector is faulty; this affects their living conditions, available time, health, stability.

II. Pollution of the canal system: Practices such as "canal discharge" of wastewater and are sources of pollution for the canal system. Its low water quality affects living conditions of inhabitants residing near it, agricultural production that depends on its water for irrigation, amongst others.

III. Aquifer pollution: Certain areas of the case study function as aquifer recharge sites, when practices such as "septic pit" and "crack or slope discharge" are realized there is a possibility that this wastewater will infiltrate, reach and contaminate the aquifer. This could present a health hazard that would affect all inhabitants receiving water extracted from the aquifer.

IV. Health hazards: Several actual practices such as e.g. the direct use of canal water for irrigation generate a health hazard.

Figure 4: Canals in flat parts X. **Figure 5: House in hilly parts of Xochimilco**

Table 6 shows the mix of technologies for each scenario for which the technical feasibility was proven.

In Scenario 1, *Local identity*, potable water will be provided through the application of rain water harvesting (RWH) systems while gabion dams will be used to increase the aquifer's recharge. Wastewater will be treated with several types of on-site technologies, adapted to terrain type and household's needs; the effluent will be reused in agricultural irrigation. Solid waste will be processed by on-site composting technologies that generate agricultural inputs as a by-product. In this scenario the proposed technologies shall be mainly implemented at the household level.

In the scenario *Economic development* similar technologies to those proposed in scenario 1 are applied; the main difference is that communal level technologies are emphasized instead of household level technologies. RWH systems are considered to be communal, wastewater treatment technologies will provide for several households (in some cases over 60) and solid waste will be collected and transported to a central composting site.

In the scenario *Integration into Mexico City* potable water will be provided by the conventional method of extending the centralized system that serves urban zones into the case study area. By the same token, the centralized sewer system that serves urban zones will be extended into the case study area and wastewater would be transported to a local treatment plant for treatment. Finally, solid waste will be separated by the users, collected and transported outside of the case study area for composting.

Table 6: Technical feasible options for the three scenarios (X = key technology in this scenario, X = complementing technology)

		Local identity	Economic development	Centralisation
Water supply Technologies	On-site RWH with tUVo	**X**	X	
	On-site communal RWHS		**X**	
	Gabion dam	X	X	X
	Improvement of existing centralised water supply	X	X	
	Connection to centralised water supply			X
	Treatment of channel water in biofilters	**X**	**X**	
Wastewater technologies	Ecosan systems	**X**	X	
	Biofilters (grey wastewater)	**X**	X	
	Constructed wetlands (household level)	**X**		
	Biostar		**X**	
	Connection to centralised sewer system and treatment in WWTP			**X**
Solid waste technologies	Biodigestor (On-site biogas plant)	**X**		
	Waste separation and on-site vermicomposting	**X**		
	On-site domestic composting	**X**		
	Centralized composting of OW		**X**	**X**

Mexico: Examples for alternative technologies

Rainwater harvesting (RWH)

The harvesting, storage and utilization of rainwater at domestic level is an alternative to avoid the overexploitation of the underground aquifers and the surface water sources in the peri-urban areas of the México city. This will be possible in the rainy season and part of the dry season. The average annual precipitation in Xochimilco is 807 mm (SMN 2012), with the majority falling in June till October. The collected rainwater will be stored in storage tanks before use. The capacity of these storage tanks will depend on the water demand as well as if there are also connections to the centralized water supply system. As the average weekly household water demand is 0.8 m³ (with each household consisting of 4 individuals and based on households with flush toilets as well as pit latrines) a total water amount of 3.5 m³ is needed per month. In general, the roof surfaces of houses in the peri-urban areas of Xochimilco are estimated to be around 36 m². Assuming a 70 per cent collection efficiency (losses and diversion of the first flush) 4.3 m³ of rainwater can be harvested in the month with the highest monthly precipitation (July; 172 mm) and 0.2 m³ in the month with the lowest precipitation (December; 6.6 mm).

The installation of RWH technologies can result in an indirect improvement of the living conditions of the inhabitants due to the improved roofs and supporting structures and a direct water saving is achieved. This will indirectly affect the environment, as less water will need to be extracted from the aquifer or canals. The water can be treated in the house with filtration, and/or a uv-light (a tUVo, requiring energy) or chlorination.

Through the implementation of an on-site RWH system with post-treatment the inhabitants will be less depended on the centralised water supply system for their water supply. If all annual precipitation (807mm) is collected with a 70 per cent efficiency on the before mentioned roof surface (36 m2), this can result in a capturing of ~20 m³ per family per year.

Biogas plant for organic waste

This biodigestion technology basically consists of recipients for gathering organic matter that is deposited to anaerobic digestion tanks designed to treat organic waste using anaerobic bacteria. This process generates methane which is collected and used on household level for instance for cooking.

The operation of a biodigester for the production of biogas is carried out by means of anaerobic bacteria present in the reactor that digest in a natural way the organic matter and produce methane. This gas, denominated biogas, is captured by the biodigester and stored in the reservoir, to use later for cooking. On the other hand, the digested waste generated in the biodigester can be used as organic fertilizer, as the input consists of an organic solid waste and manure with a high nitrogen and phosphor content. In Xochimilco several households have bovine livestock, from which the manure could be recovered and used in combination with the collected organic waste as a source for the generation of biogas.

Urine diversion dry toilet system

By constructing dry toilets at households that currently do not have sanitation facilities or make use of pit latrines access to proper sanitation facilities is improved. As it is generally the poor who do not have proper access, their livelihoods and the overall public health is impacted directly and improved. In addition, the recovery and reuse of nutrients can not only lead to less demand for artificial fertilizer (or if no fertilizer was used, higher yields), but it can also improve the soil conditions and thereby the sustainability of the land.

An dry toilet can be constructed in the yard of a household, or as an extension of a house, where in general the dimensions of a toilet or pit latrine (1m²-1.5m²) can be maintained. Care should be taken to design the dry toilet in such a way that it uses energy from the sun to dry the collected faeces. Faeces and urine will be stored in two separate containers prior to their use or the co-composting. The faeces and urine can be used in local gardens, greenhouses or chinampas in the form of compost.

The implementation of a dry toilet for the treatment of faeces and urine at household level will enable the recovery of nitrogen (N), phosphorus (P) and Potassium (K) as well as water.

Figure 6: Rainwater harvesting structure

Figure 7: Biogas plant.

Argentina

The existing technologies for households and institutions in the case study area of Delta Tigre are presented in the next table.

Table 7: Existing technologies and practices in the case study area

Water supply and water treatment	Sanitation	Wastewater treatment	Irrigation	Organic solid waste
• Bottled drinking water • River water • Harvested Rainwater Treatment (of RW): • chemical coagulation • $(Al_2SO_4^3)$ + disinfection (NaClO) • electro-coagulation (EC) + disinfection (manual/ automated)	• Individual solutions • Wet toilet with raw river water	• Septic tanks • Natural wetland sewage disposal • River dumping of raw sewage	• Few small-scale reed harvesting • Few and dispersed family gardens • Marginal and small scale wood production	• Barge collection of non-classified garbage • Burning of garbage as a usual practice

The main problems that need solution in the management of natural resources of the case study area are related to:

I. Provision of water at an adequate price: ensure that the island population adequate drinking water at an affordable price. Nowadays water is an expensive good (in price and in time);
II. Improve water quality of the river: the discharge of loads of pollution from the Reconquista river basin are degrading the environmental conditions of the islands and make it more difficult to obtain water from surface courses for consumption;
III. lack of water quality data from monitoring programs is a serious constrain because people tend to think that the quality of rivers and streams is the same throughout the area when in fact, there are areas where river water quality is very poor and should not be used for domestic uses or should be treated differently to render drinkable water;
IV. household sanitation infrastructure (water and sanitation) should be under control due to the impact it represents on the health of the population; an information system that alerts islanders on the health hazard linked to water pollution is also needed; finally, tourism, also fostering navigation-transport activities is primarily responsible for the generation of wastes, both activities must be regulated to avoid adverse effects on the environment and tension with Delta-Tigre permanent residents.

Figure 8: House in the Islands of Tigre

Figure 9: Water bottles at the continent waiting for their transport to the Islands of Tigre

Table 8 shows the technologies used under the different concept scenarios.

The concept scenario *Green Delta* favours natural technologies which support environmental protection and independency of continental Tigre. Local water resources (river and rain water) are collected and treated. On-site sanitation systems with emphasis on reuse of nutrients or organics can supply users with compost and biogas. Organic waste is separated and composted and the compost can be used in local gardens which supply people with vegetables and flowers.

In the concept scenario *Economic development*, treated river water is the main water source. Different treatment methods, depending on the size and needs of the household/institutions are used. Households will still use on-site systems, and the effluent of some neighbouring houses may be treated communally in constructed wetlands. In hotels and restaurants, variable waste flows need to be managed as the number of tourist is increasing on weekends and holidays. Therefore compact treatment plants will be used as they need little space and are robust.

In the concept scenario *Centralisation* infrastructure services are centralised as far as possible. Users close to the continent are connected to centralised water supply and solid wastes collection systems. Areas far away from the continent will use alternative technologies.

Table 8: Technical feasible options for the three scenarios (X = key technology of this scenario, X= complementing technology)

Technologies		**Green Delta**	**Economic development**	**Centralisatio n**
Water supply - households	On-site rainwater harvesting and solar disinfection	**X**		X
	Bottled water	X	X	X
	River water treatment with electro-coagulation (EC)		**X**	
	Groundwater treatment in reverse osmosis (RO) system		**X**	
	Coagulation and settling of river water (non-drinking)	X	X	X
	Connection to centralised-continental water supply net			**X**
Water supply - institutions	Bottled water	X	X	X
	Compact water treatment plant:	X	**X**	X
	River water treatment with electro-coagulation (EC)	X	**X**	X
	Groundwater treatment in RO system			
	Connection to centralised water supply net			**X**
Wastewater/ sanitation - households	Flush Toilet, Septic Tank, Anaerobic Filter (AF) and Natural Wetland (NW)	**X**		X
	Grease trap and NW for grey water	**X**		X
	Biodigester and NW	**X**		
	Flush toilet, septic tank and constructed wetland for HH		**X**	
	Connection to island based centralized wastewater treatment plant (only for those that would have the centralised water supply network)			**X**
Wastewater/ sanitation - institutions	Flush Toilet, Septic Tank, Anaerobic Baffled Reactor (ABR) and Natural Wetland (NW):	**X**		
	Grease trap and NW for grey water	**X**		X
	Biodigester and NW	**X**		
	Biogas settler and NW	**X**		
	Septic tank and constructed wetland		**X**	
	Compact wastewater treatment plant		**X**	
	UASB and NW		**X**	
	Connection to centralised wastewater treatment plant (only for those that would have the centralised water supply network)			**X**
Solid waste technologies	(Vermi-)composting	**X**	X	X
	Barge collection of organic waste		X	X

Argentina: Examples for alternative technologies

Electro-coagulation (EC)

Removal of river water turbidity in Delta-Tigre can be performed by Electro-coagulation (EC) in both households and institutions (e.g. schools). The process consists of electro-coagulation (EC), microfiltration and disinfection or river water and aims a reaching drinking water quality. This technology is employed today in Delta Tigre by few islanders and two schools to provide cleaning, cooking and toilet water. Although design and O&M improvements are pending in order to reach a drinking water quality.

Biodigester for black water

The treatment of blackwater from flush toilet by using a prefabricated biodigester and a final disposal of the effluent into a natural wetland may be a sanitation technology applicable to both households and institutions in Delta-Tigre. The biodigester replaces the septic chamber with the advantage of the availability of this equipment in the local market. Two models of prefabricated Biodigesters are supplied under the trade mark ROTOPLAST in Argentina. They have a volumetric capacity of 600 and 1300litres, respectively. A rotational movement separates sludge and scum.In Delta-Tigre islands, the Biodigesters may be installed under the elevated houses, although they will be subject to periodic river flooding. However, they will not be filled with river water if the system is adequately sealed. A biodigester produced biogas, which can be used for heating, lighting or cooking. This will require the installation of a gas storage device as well as a pipe to transport the gas to the device. In theory 1 kilogram of COD in the digestate can produce 0.35 m^3 methane. The amount of COD present in the different waste types will differ of course, and this should be determined beforehand to ensure that the expected prodution of biogas is possible.

(Vermi-) Composting

In order to reuse solid wastes generated in Delta-Tigre households, garbage material should be classified (organic, metallic, paper and cardboard, plastics, glass and hazardous wastes). Garbage classification allows that organic wastes may be composted and reused as a fertilizer in local gardens growing vegetables and flowers. For (vermi-) composting of organic solid wastes in households a floor is constructed on which the composting bed can be created. This basically consists of organic waste. In the case of vermi-composting nuclei of worms (*Eisenia foetida*) are introduced. Hackels and poles will be used to turn the organic matter, and rakes will be used to remove the worms from the compost that is collected. Organic solid waste composting in Delta-Tigre will be able to reduce garbage transport and disposal of waste at the continental sanitary landfill and decrease local fertilizer demand.

Figure 10: Electro-coagulation system implemented at a school

Figure 11: Biodigester installed at the Islands of Tigre

Economic impact assessment

VIVACE has aimed at capturing the impact of natural resources management on the regional economic development. At the beginning of this task VIVACE has summarized the key contributions of the VIVACE sectors to economic development following the concept of the total economic value. Use values can be distinguished into direct and indirect values, which are based on the valuation of direct and indirect benefits. In addition to use values, there are also non-use values. The reduced pressure on water resources due to the reuse of treated wastewater is an example for a non-use benefit as it values the existence of intact river ecology. Other non-use value are the bequest value which values the preservation of resources for future generations and the altruistic value that values the fact that others can enjoy cleaner water bodies.

Most important in the context of VIVACE are the use values. Use values can be further classified into direct and indirect values. Direct values are defined as immediate benefits related to the provision of service infrastructure. Four main direct use values have been identified: improved hygiene, reduced water pollution, provision of infrastructure and provision of (possible) resources. Indirect benefits are consequences of the direct benefits such as decreased incidences of water related diseases and cleaner water bodies. As an example, Figure 12 gives an overview of direct and indirect benefits related to improved sanitation and wastewater management.

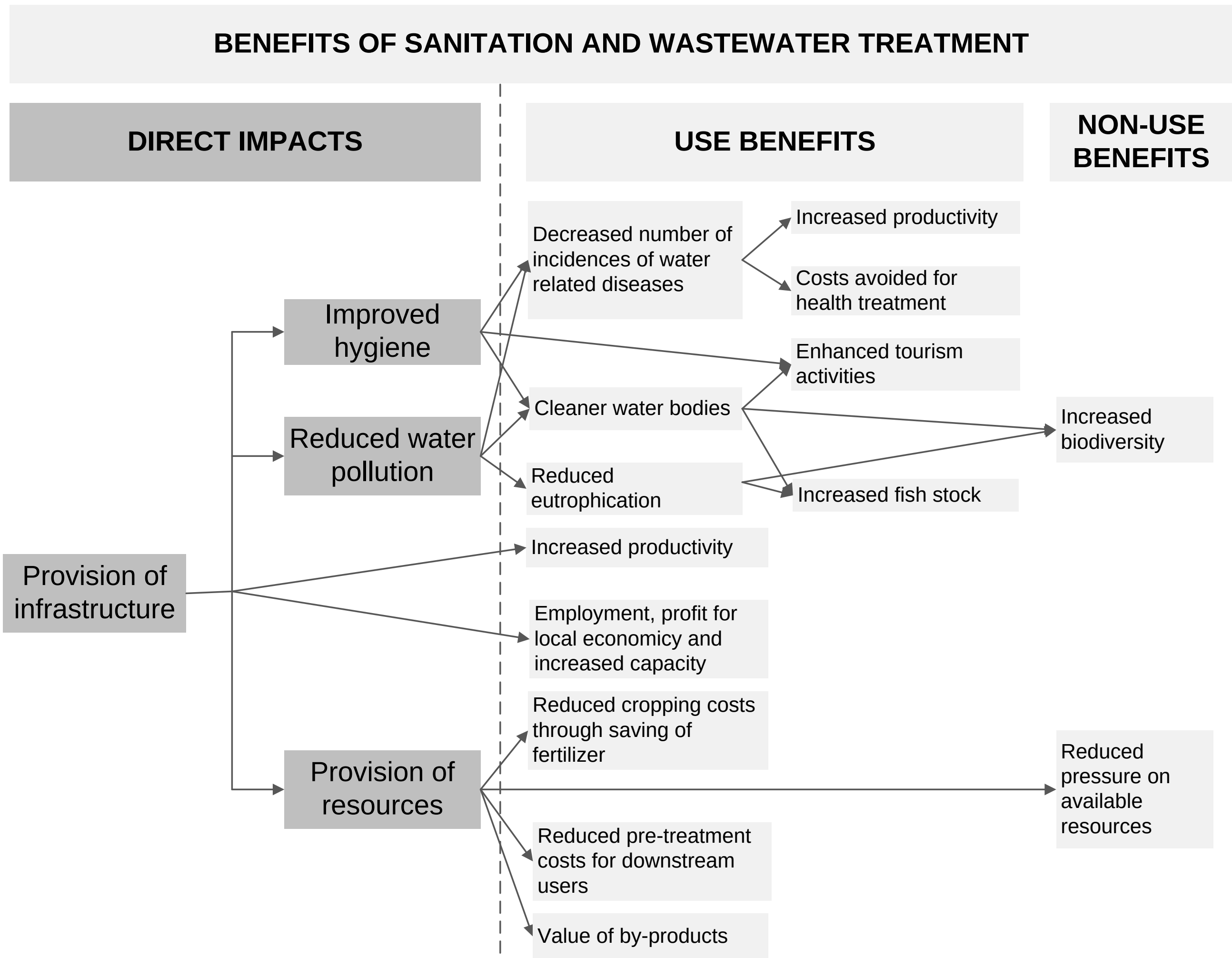


Figure 12: Benefits of sanitation and wastewater treatment

In this study the most relevant benefits stemming from the “VIVACE” technologies were identified by local experts and then the value of those benefits were assessed.

In Mexico the following benefits have been considered for the impact assessment:

- Service reliability and quality
- Time requirement
- By-products
- Employment
- Health
- Canal system contamination
- Aquifer contamination
- Aquifer recharge

In Argentina in addition the following benefits have been considered:

- Reduction of emissions
- Education and capabilities generation

To assess the economic impact, a mix of methodologies has to be applied, in order to capture and monetize, as far as possible and reasonable, the impacts of the technical interventions promoted by VIVACE. As shonw above, VIVACE has mainly used qualitative indicators such as time requirement, service quality, health or employment. The results have shown that all three concept scenarios have substantial positive impacts on the economic development compared to the status quo. This is mainly due to less time requirements for water supply (e.g. instead of collecting water bottles from the continent in Tigre water will be locally available), reduced health costs due to better hygienic conditions and a better service quality.

The study has further shown that certain indicators depend more on the technologies (e.g. health, time requirement) and because the chosen technologies of the three concept scenarios differ only little with respect to those indicators, the three concept scenarios did not differ significantly with respect to their economic impact related to those indicators. However, other indicators such as employment or education depend more on the overall scenario assumptions (e.g. population growth) and are hence less dependent on the chosen technologies.

Figure 13: Cattle in Xochimiloc

Figure 14: Boy catching fish in the canals of Xochimilco

Application of an integrated assessment approach

Integrated assessment shall ensure that all aspects that are relevant to achieve sustainable service provision are adequately considered when deciding for technical alternatives. “Our Common Future” of the “World Commission on Environment and Development” (Brundtland report) already defined sustainability in 1987 as a “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987). To reach sustainable development, the three dimensions of sustainable development – economic development, social development and environmental protection – have to be treated as interdependent and mutual reinforcing pillars (United Nations General Assembly 2005). Figure 15 shows typical illustrations of this concept.

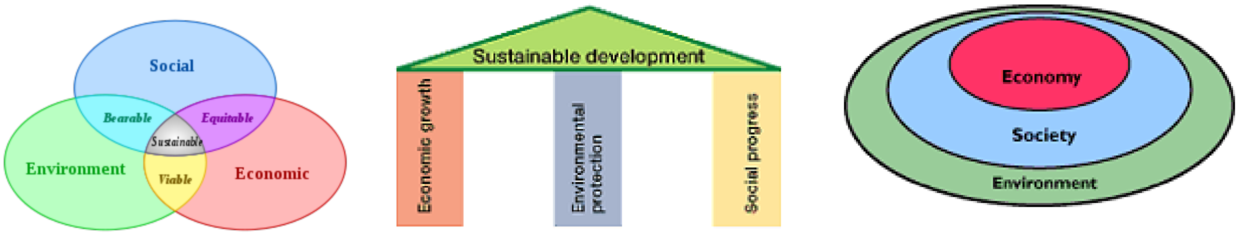


Figure 15: The three dimensions of sustainability (IUCN 2006)

Methodology

The following novel framework for a participative and integrative appraisal of sustainability was applied. Scenario development was used as a tool to raise awareness amongst stakeholders, resulting in three scenarios (explained above). Feasibility studies identified technically feasible options that were characteristic for each scenario (explained above). These technologies were evaluated on the basis of the three dimensions of sustainability, namely the economic, social and environmental impact and risks of these options, and the results were discussed by stakeholders in focus groups (see below). Thereby, the criteria were developed with the participation of the interested institutional stakeholders (explained above). Finally, decision support tools identified the most sustainable option(s).

The last step depends on the identification of what possible trade-offs are accepted by the relevant stakeholders. This identification is crucial for participatory assessment, which aims at supporting stakeholders finding a consensus about their final solution. Hence, the preferences of the stakeholders should decide about the relative weights of the criteria. To this end, a novel application of the analytical hierarchy process (AHP) was used to elicit (hidden) individual preferences: Respondents were asked to pair-wise compare the importance of the criteria and AHP translated these qualitative responses into quantitative criteria weights together with an assessment of the consistency of each answer. Data were analyzed by means of agglomerative iterative clustering with the aim of identifying a consensus clusters about the relative importance of the criteria and these clusters were modelled by the CHAID classification tree method to explain the preference pattern.

However, data have shown that there is no consensus about trade-offs, neither between institutional key stakeholders, nor between users, except for the consensus about the importance of environmental aspects. The displayed figure illustrates a social network analysis of the Mexican stakeholders and users: On the one hand, there is an environmentally minded group (green, and yellow, which indicates less consistent responses), on the other, there are groups (blue, red) with more emphasis on other issues, in particular user interests. Moreover, preferences differed between villages within a case study area.

Thus, there is a consensus about the importance of environmental issues, whence new technology should not be implemented without careful consideration of the expected environmental impact. Yet, decision making cannot ignore the other criteria, either, as each criterion was supported by stakeholders. If a technology is inacceptable with respect to any of these criteria, then it should not be implemented, as otherwise important societal interests, as represented by the institutional stakeholders, could be violated. Therefore, in this study the only aggregation method based on trade-offs that was applied was a simplified cost-benefit-analysis. Here the trade-off was defined by the monetary value of the benefits stemming from recycling and reuse of water, energy and nutrients. These benefits were directly compared with the costs of the technologies and the trade-off with costs was obvious and uncontested.

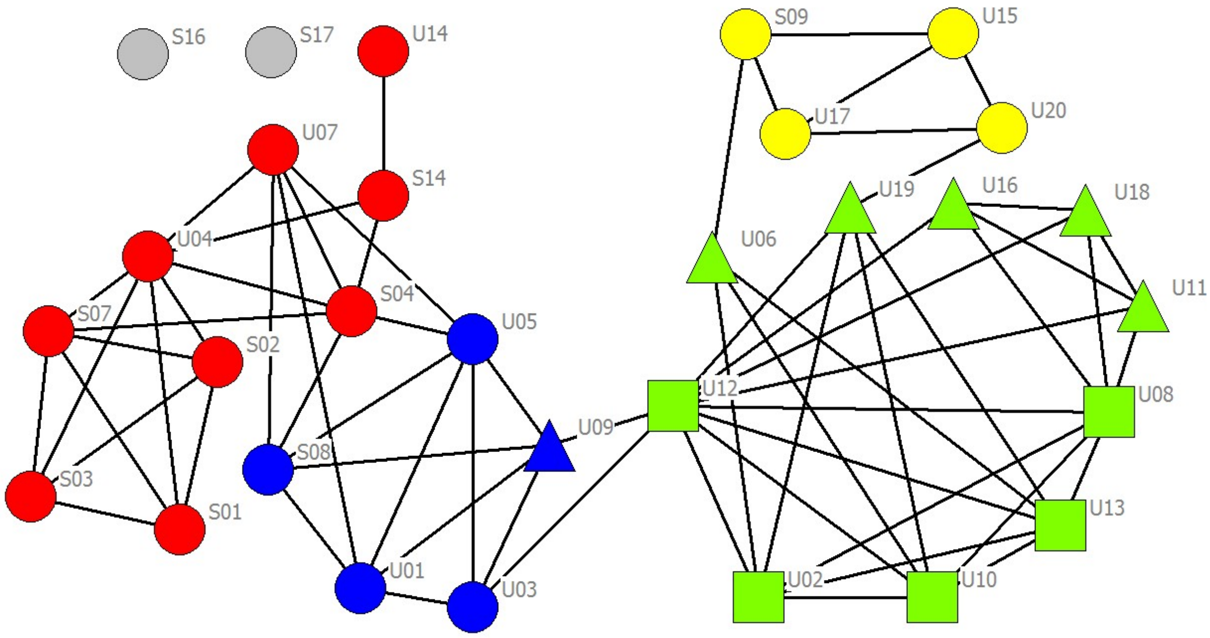


Figure 16: Display of Mexican responses: strong correlations and the resulting classification.
Explanation. Nodes represent respondents, colours their preference class, shapes their eigenvector centrality (Google Rank: circle = below one third of the maximum observed centrality, triangle = medium, square = above two third of the maximum centrality), and lines connect respondents with strongly correlated responses.

Environmental assessment

The environmental assessment encompassed the criteria water conservation (water demand covered by rainwater harvesting and wastewater reuse), energy use of technologies, potential nutrient recovery and water and soil pollution. Local data for precipitation, water consumption, waste(water) amounts and composition, treatment technology efficiencies and energy consumption were used, complemented by literature data and expert estimations where needed. Using this information the water demand of the area, the available amounts of harvested rainwater and treated wastewater, required energy and amounts of potentially recoverable nutrients were calculated for the different technologies.

Economic assessment

For the economic assessment, investment and operation and maintenance costs were calculated based on literature data, market prices and information of already implemented projects. In addition, the monetary value of the resources water, nutrients and energy were considered. With these data then the net present value (NPV) for all options over a period of 30 years was calculated with discount rates of 2% and 10% to see how the costs for the user or the government develop over a longer period. For the centralised system, the number of people that can possibly be connected to the treatment plant was calculated. The costs per user are based on this number. With respect to the monetary value of resources, if possible, the market price of these resources was used. If no market price is available as for urine and biogas, the value of nutrients (or energy content in case of biogas) was calculated comparing it with the product that is substituted.

The labour input of users was included in the operation costs with a value of 16M$ or 12ARS per hour which is based on a local survey. All values were adjusted to the year 2012 by using the inflation rate of the construction sector.

Social assessment

The social assessment encompassed user acceptance, impact on users and institutional compatibility. User acceptance was assessed based on two focus groups that were conducted in the case study area. Impact on users was assessed through five sub-criteria which examined the required changes of users compared with the current practice. Institutional compatibility was assessed by four sub-criteria which examined how well suited the options are to the current institutional conditions in the case study area. The impact on users and the institutional compatibility were judged by local experts, who assessed each criterion on a scale from one to five, with a score of one meaning low impact or high suitability.

Figure 17: Focus group in Delta Tigre

Figure 18: Focus group in Xochimilco

Table 9 shows the list of criteria, the method of assessment and the source of information that has been used for the social assessment.

Table 9: Criteria used in the integrated assessment

Criteria	**Method of assessment**	**Source of information**
Environmental assessment		
Water pollution	Removal of BOD, N, P Pollutant loads, number of users and technical systems, Removal efficiencies	Information from existing systems, (sampling), literature
Soil pollution	Cadmium in side products	Literature data
Recycling of nutrients	Nutrient flows	Literature, general removal efficiencies
Energy use	Energy flows	Information from existing systems, estimations
Water conservation (only Mexico)	Water flows	Literature and field data
Consumption of chemicals	Qualitative judgement	Information from existing systems
Health risk	Qualitative risk assessment (based on WHO approach)	Expert judgement
Biodiversity	Qualitative judgement	Water pollution assessment, literature
Economic assessment		
Investment costs of technologies	Cost calculation	Collection of information from existing systems, literature, own estimations, input for NPV
Operation & maintenance costs of technologies	Cost calculation	Collection of information from existing systems, literature, own estimations, input for NPV
Social assessment		
Level of acceptance of users	Focus groups	Users
Impact on users: • Required changes of cultural habits of users • Operation requirements by users • Required knowledge and skills of users • Required changes in the house • Quality of ambience (e.g. noise, aesthetic value, odor)	Qualitative assessment	Expert judgment (scale 1-5) 1- low impact (e.g. no change of habits, operation not conducted by user, no changes in house, etc.) 5 – high impact (e.g. high required change, knowledge, changes in house, time consuming operation, etc.)
Institutional compatibility: • Compliance of technologies with legal requirements • Capacity of existing local institutions to provide technical support • Existence of institutions to monitor & control the technologies • Information on required institutional support measures	Qualitative assessment	Expert judgment (scale 1-5) 1 – well suited to current institutional framework (e.g. compliance with legislation, existence of all institutions, no external support required, etc.) 5 – not suited to current institutional framework (e.g no compliance with law, external support required, no institutions for monitoring, etc.)

Results

Rainwater harvesting systems (RWH) in Mexico would be more suitable, where rainwater could cover the whole demand of a family. In the case of Xochimilco, only a part of the domestic demand during rainy season can be covered, which makes the extension of the centralised net necessary. Concerning the costs, there were large differences between the individual and the communal system: the communal system was more expensive as a separate structure to capture the rainwater is necessary and water is distributed in a local network. Participants in the focus groups preferred the individual over the communal RWH system as they want no communally managed system.

Also in Argentina, RWH was not a preferred option as participants of the focus groups think that there is enough river water to be used and no additional water source was necessary. When looking at the entire case study area in Argentina, taking into account the fraction of the population that would use RWH according to the technical feasibility study, in scenario 1 RWH would cover 32% of the domestic drinking water demand. In scenario 3 this is 10%.

Even though bottled water needs to be transported in boats to the single houses, it is a cheap option for households in Argentina. Users accept it as safe water source but are aware that it is not environmentally sustainable option, due to the emissions related to transportation of bottles (usually by means of fossil fuels consumption), the production of water in the water treatment plant and the potential pollution caused by mismanagement of discarded bottles.

The treatment of river water in Argentina with electro-coagulation or ground water by means of reverse osmosis is an expensive option for households and institutions. The systems are accepted by users but the high costs make them only affordable for few people on the islands. Both technologies need chemicals to clean the electrodes or membranes, respectively. In addition, the electro-coagulation technology employs chemicals for the disinfection of water. Both technologies will need energy for operation, although the reverse osmosis technology requires more than the electro-coagulation.

The expansion of centralised water supply technologies have high energy requirements and a demand for chemicals for operating, cleaning and disinfection is expected while no water is conserved and the already overexploited aquifers are depleted even further. This option is preferred by participants in both countries and it is in both countries a cheap option.

Ecosan is a good sanitation option to reduce water demand, and together with RWH can help in providing a situation in which people can have sufficient water for their needs without depending on the centralised supply. Treating grey water in a biofilter for local reuse adds extra water savings. If these technologies can be successfully applied in Xochimilco this could serve as an incentive to explore the option also for other areas in the city. Participants of the focus groups had a positive attitude towards Ecosan and demanded a pilot plant in the area. With respect to costs, the system performs similar to the centralised wastewater treatment system.

The constructed wetland at household level in Mexico had higher costs than the Ecosan system, but requires less labour input from the users and is also for houses that do not practice agriculture, an interesting option. In Argentina, it was only accepted by some participants as there was the general opinion that natural wetlands are preferred over constructed ones.

The proposed constructed wetlands do not require pumping, so there is no need for energy. In addition, constructed wetlands do not need chemicals to treat the wastewater and sufficiently remove organic matter, nitrogen en phosphorus from the wastewater. Hence, their good environmental performance makes them an interesting option for application in the case study area.

The septic tank with anaerobic filter is not preferred by the users as they have already septic tanks and think that an upgrade with the anaerobic filter will bring no additional benefit. The system has similar costs as the other on-site options.

As mentioned earlier, anaerobic filters produce biogas. If the biogas is captured and flared off or reused the environmental impact of an anaerobic filter can be lessened. Other environmental impacts will be the energy requirements for pumping the wastewater and relative poor N and P removal efficiencies. Recycling of nutrients in the form of sludge and effluent is possible.

The biodigester in Argentina is considered to be more appropriate for institutions than for single households. The economic benefit of the biogas is very low as there is only little production from the three users per system in houses. For institutions it is an interesting option. The costs are in the same range as for other on-site treatment options.

Due to the design and characteristics of a biodigester it allows for moderate to good nutrient removal from wastewater as well as better recycling possibilities due to the higher amounts. If properly designed no pumps are needed and hence there is no demand for energy.

Decentralised biostar systems provide adequate wastewater treatment, protecting public health and the environment without the large economic and infrastructure impact of a centralised wastewater collection and treatment system. The biostar system was not preferred by the participants in the two focus groups as they did not opt for a decentralised solution, but preferred on-site and centralised systems. The investment costs of the biostar were in the range of the constructed wetland at household level.

Connection to the existing centralised WWTP could be an option for those that live close to the existing sewers or the continent, but in other cases connection can be difficult due to the nature of the terrain. Decentralised treatment (individual or communal) looks like the better option for peri-urban areas, also because the population density is not evenly spread. Nevertheless, participants in the focus groups preferred the centralised option and it turned out to be a cheap option if technically feasible.

Composting is a well accepted technology in both countries and already practiced by many people in the islands of Tigre. It is a cheap option for the treatment of organic waste, brings the benefit of compost and requires no energy.

The vermi-composting is the most expensive solid waste technology in both countries, but users have the opportunity to sell the worms or use them as cattle feed. This benefit was not considered in the assessment, as it is not known whether all of them would be interested or willing to sell their worms. The benefit of the worms can be higher than the O&M costs as they multiply at least tenfold within one year. Participants in all focus groups had a positive opinion about vermi-composting.

Only the centralised collection and composting facilities require energy for its operation. Nevertheless it has the lowest NPV of the evaluated options and is preferred by the users.

Conclusions

The study has shown that a management alternative that aims at maximisation of resource conservation may not be cheaper than a conventional management approach. This result is interesting as the cost calculation included already the monetary values of conservation, reuse and recycling of resources.

This result gives rise to the question whether the cost of resources are too low. Issues such as a too low water price are well known but this may also be the case for the costs of nutrients and energy. If the cost of those resources would increase then the cost calculation would become more in favour of conservation and reuse& recycling alternatives.

The study has also shown that technologies of scenarios *Local identity* and *Green Delta* would impose a bigger burden on users as they would require more user responsibility. However, focus groups have shown that users would be prepared to take those responsibilities even if the overall preference would still be towards provision of centralised services. Therefore it is not sure, if users would really be willing to operate such systems themselves over a longer period. Mechanisms, where professional organisations can take care of the operation and management, need to be explored (they will cause higher costs).

Finally, the study confirmed that the alternative technologies are less compatible with the existing institutional system (regulations, laws, capacity of existing institutions). Therefore, substantial investments need to be provided for training and awareness raising activities. Existing regulations and laws may deter the implementation of alternative technologies.

Management alternatives aiming at conservation, reuse and recycling of resources are very beneficial, but need to be supplemented with a policy and institutional framework that is clearly supportive of such alternatives to ensure their overall sustainability.

Policy recommendations

The policy recommendations have been developed with project partners and invited external experts and stakeholders in order to discuss the project results and to discuss their possible implications on existing policies. The outcomes of these workshops were “policy briefings” that summarize the policy relevant work of VIVACE and the resulting policy recommendations.

Figure 19 and Figure 20: Policy workshop in Argentina

In total three policy briefs were elaborated: One for Mexico, one for Argentina and one summarizing those policy recommendations that are expected to have a wider relevance for the Latin American region. The latter policy recommendations are listed below:

- Recognizing that service provision may be more difficult in peri-urban areas compared to urban areas, urban policies need to provide guidelines on the development of peri-urban areas.
- Recognizing that despite the principle of “economies of scale” centralized solutions may not always be suitable to cover peri-urban areas, alternative on-site and decentralized technologies may in certain circumstances be a good alternative for solving the challenges in peri-urban areas. Reuse of resources (water, nutrients, energy) can provide additional revenues.
- More information on advantages and possible risks and guidelines on their application needs to be provided for alternative technologies that are easily accessible to local stakeholders and interested users. The scope of application of such alternative technologies shall be actively promoted among stakeholders (including providers of centralized services). Laws and regulations need to be reviewed with respect to their compliance to the needs of such alternative technologies.
- Recognizing that the available budget may not always allow local governments to provide appropriate infrastructure services, an unambiguous definition of roles and responsibilities of institutions with respect to financing, implementing and monitoring/control of infrastructure as well as

for (pro-poor) cost recovery is required. This shall be supported by appropriate government policies (at each level) that define suitable targets for improving infrastructure and financial resources needed for implementation.

- Recognizing that successful infrastructure provision needs a joint effort of stakeholders, provisions for better communication of stakeholders need to be provided (e.g. between different levels of government). Better use of already available resources such as at research centers, universities or NGOs should be made.

- Recognizing that local populations have substantial knowledge, the potential of locally evolved technologies should be taken into account for meeting future demands.

- Recognizing that investments into water and waste infrastructure have enormous direct and indirect benefits for the public and private sector, a mixture of public and private funding shall be mobilized for financing infrastructure. Public and private sector should synergize their resources. Awareness about the economic value of water services needs to be increased. Studies that identify the full economic value of direct and indirect benefits shall be supported.

- Recognizing that operation& maintenance is crucial for long term sustainability of any infrastructure, funding policies should allow for funding of training activities and for funding of operation& maintenance work. In this context, policies should be made that make it mandatory that infrastructure is subject follow up and monitoring also years after implementation. Financial resources need to be provided for that purpose.

- Recognizing the importance of trained staff for successful operation& maintenance and the possible practice of changing staff with newly elected local governments, provisions need to be made to ensure continuity in the local knowledge required for O&M. Community based organizations should be supported for this purpose.

Specific policy recommendations for planning

- The planning should be based on a watershed/catchment approach rather than on a localized approach.

- A variety of on-site and decentralised technologies for water and waste management that can be applied in peri-urban areas as an alternative to conventional centralized systems exist. However, which solution is most sustainable depends on the local context and hence no standard solutions can be recommended.

- As a consequence, a comprehensive planning and assessment of different solutions is required. A participatory planning starting from a scenario analysis to identify possible development options can help to raise awareness and interest among stakeholders and users and hence to provide the basis for a successful planning process. Appropriate forms of stakeholder involvement considering the local situation shall be applied.

- The planning process shall encompass an initial technical feasibility analysis of a variety of technical options. After the initial technical feasibility has been assessed, economic, social and environmental aspects shall be assessed for all technically feasible options. The assessment results shall be presented to and discussed with the stakeholders and users.

- An economic assessment shall encompass investment and operation& maintenance costs. The latter is most important for the long term financial sustainability. A cost estimation should encompass the investment and the O&M costs for at least 15-20 years and preferably over the whole life cycle of the assets to be created (ideally 30-50 years). Capital investment, re-investment, annual recurring costs (O&M), and benefits should be quantified to select economically viable technologies. The O& M cost may include the personnel and material cost for regular operation, repair and maintenance work, costs for energy and other consumables. The economic benefits associated with the technology such as biogas, fertilizers or water for reuse should also be calculated. At the feasibility stage, the various options for sanitation technology can be compared with the total net present value (NPV). A NPV calculation compares between different options future investment and operation costs over a defined time span using one or more discount rates applicable to relevant market conditions. By using this technique, it is possible to compare trade-offs between present capital costs and future running costs and benefits.

- A social assessment should ensure involvement of the future users and stakeholders in the planning process so their needs and wishes can be adequately taken into account. In particular the needs of deprived groups need to be considered. The affordability and options for financing of the system should be investigated and a financing plan prepared that covers both capital and operational expenditures. Thereby, the full range of public and private financing sources should be considered. Arrangements for operation& maintenance should be investigated in the light of the required capacity for operating and financing the system.

- An environmental assessment should answer questions such as: What is the required effluent quality of the treated wastewater? Where can effluents be discharged? Are there any hygienic concerns? What are the benefits to be derived from use of by-products such as biogas, fertilizer or reused water? However, many of these may provide environmental benefits not just cost benefits (e.g. if saving of water may be regarded contributing to an environmental goal).

- Technical guidelines and information about alternative technologies and assessment techniques need to be provided by local competent institutions and disseminated among stakeholders and possible users.

These policy recommendations are supported by the following stakeholders:
Mexico: IMTA (Instituto Mexicano de Tecnología de Agua), ANEAS (Asociación Nacional de Empresas de Agua y Saneamiento, CONAGUA (Comisión Nacional de Agua), Universidad Autonoma Metropolitana, SARAR Transformación.

Argentina: Argentina: IIED-AL (Instituto Internacional de Medio Ambiente y Desarollo – America Latina), INA (Instituto Nacional de Agua)

Europe: BOKU (University of Natural Resources and Life Sciences, Vienna, CEMDS (Centre for Environmental Management and Decision Support), LeAF (Lettinga Associates Foundation)

International: UN Habitat, LA WETnet, International Water Association-Specialist Group on Water and Sanitation in Developing Countries, FANAS (Freshwater Action Network South America)

POTENTIAL IMPACT

Expected impact

The expected impact of the topic addressed by VIVACE has been "*Fostering participatory and constructively engaged international co-operation in the field of integrated resource management in order to support attaining the Millennium Development Goals (MDG) targets and the need to preserve and use resource in the most possible way and getting research results considered by the spectrum of societal actors in Latin American cooperation partner countries".*

In order to help VIVACE to achieve this expected impact five provisions were suggested in the proposal. They substantially contributed to VIVACE's success in achieving its expected impact:

Provision 1: Focusing on highly relevant issues for the partner countries: integrated peri-urban water management

Provision 1 has been a main driver to engage with a large number of societal actors in the Latin American cooperation partner countries. Peri-urban water management has been a crucial aspect for Latin America throughout the project implementation and continues to be an important issue in future. This will ensure a high potential impact of the work carried out in VIVACE also after the end of the project. The importance of the topic of VIVACE has also been highlighted by the Ministerial Statement Nr. 5 of this year's 6th World Water Forum, which states that "*an integrated approach towards sanitation and wastewater management, including collection, treatment, monitoring and re-use, is essential to optimize the benefits and value of water. We need to advance development and utilization of non-conventional water resources, including safe re-use, turning wastewater into a resource, and desalination as appropriate, to stimulate local economies, and help prevent waterborne diseases and the degradation of ecosystems."*

Provision 2: Added value in carrying out the work at an European level

Provision 2 has helped VIVACE to bundle European research expertise and adapt it to the needs of Latin America and thereby present European research results to a wide spectrum of societal actors in Latin America. The VIVACE project was implemented by three leading European organisations in the field of peri-urban water management. Each of these organisations itself has been in cooperation with a large number of European organisations, allowing those three partners to effectively summarize key European knowledge in this field. For instance, for VIVACE around 20 papers, reports and theses on sustainability criteria were reviewed, which all had at least one contributing European author. Hence, VIVACE could utilize and link knowledge produced in a wide range of research projects. This contributed to an intersectional strengthening of the European Research Area. Further, VIVACE has contributed to settle the leading position of Europe in the research field of integrated water resources management, which it has achieved through continued research funding in the last three decades. Thereby, VIVACE also contributed to reinforcing competitiveness of European organisations working in the water consultancy field, such as LeAF.

Provision 3: Cooperation with several ongoing research activities

Provision 3 has further helped VIVACE to streamline international endeavours in the field of peri-urban water management. For instance, VIVACE had established active cooperation with three European FP6 projects, which carried out research on similar topics in Latin America, Africa and Asia (ANTINOMOS, DIM-SUM, MAI-TAI) and thereby could build up synergies. In addition, VIVACE established contacts and co-operations with several Latin American and international organisations such as LA WETNET, ANEAS, IWA or the World Bank.

Provision 4: Minimisation of potential risks

Provision 4 has aimed at reducing risks of multi-stakeholder interaction throughout the project. The strong Latin American partners IIED-AL, INA and IMTA of the VIVACE Consortium were of crucial importance to achieve the expected impact of VIVACE. Their reputation has ensured a high participation of Latin American societal actors in the various project components.

Provision 5: Professional communication and exploitation of project results

Finally, provision 5 has allowed VIVACE to successfully disseminate and exploit the project results at regional and international key media and events (see below).

Moreover, VIVACE has been and will be present at major regional and international events were a large number of key stakeholders has gathered, such as the Stockholm World Water Week, the Water Research Conference in Singapore or the Latin American Water Week.

Together, these 5 provisions allowed VIVACE to achieve its expected impact, in particular in "*getting research results considered by the spectrum of societal actors in Latin American cooperation partner countries*". A large number of Latin American societal actors has participated in the various VIVACE activities. Among them were several umbrella organisations such as ANEAS which encompass several hundred member organisations. Table 10 and Table 11 below summarise the involvement of Latin American actors in the different components of VIVACE.

Figure 21 and Figure 22: Discussion of research results with stakeholders

Table 10: Societal actors involved in Mexico

STAKEHOLDERS
Local NGOs and networks
Red Waterbody Federal District
National and regional NGOs and networks
SARAR
Grupo de Estudios Ambientales (GEA)
IRRIMEXICO
Freshwater Action Network (FAN-Mexico)
Asociación Nacional de Empresas de Agua y saneamiento (ANEAS) (several hundred public and private water companies)
Local government
Local government of Xochimilco
City government – Mexico City
Comisión de Recursos Naturales (CORENA)
Sistema de Aguas de la Cd. de México (Water provider Mexico City)
National government
Comisión Nacional del Agua – National Water Commission (CONAGUA)
Secretaría de Desarollo Social (SEDESOL)
Comisión Nacional para el Desarrollo de los Pueblos Indígenas (CDI)
Universities
Universidad Nacional Autónoma de México (UNAM)
Universidad Autónoma Metropolitana Xochimilco (UAM-X)
Regional organizations
UN Habitat (Mexico Office)
Local community organisations or representatives
Farmer‘s union of Xochimilco
Farmers and chinamperos

Table 11: Societal actors involved in Argentina

STAKEHOLDERS
Local NGOs and networks
Delta and Rio de la Plata Assembly
Espacio Agua
Environmental Diocesan Commission
San Isidro Sustainable Association (ASIS)
National and regional NGOs and networks
Wetlands International
LA-WETnet
Asociación Interamericana de Ingeniería Sanitaria y Ciencias del Ambiente (AIDIS) (several thousand members)
Local government
Subsecretaria de Medio Ambiente / Municipalidad de Tigre
Subsecretaría de Medio Ambiente / Municipalidad de San Fernando
Local government of Tigre
Provincial government
Organismo Provincial para el Desarrollo Sostenible / Provincia de Buenos Aires
Federal government
Protección Ambiental del Río de la Plata y su Frente Marítimo: Prevención y Control de la Contaminación y Restauración de Hábitats (FREPLATA) in the Secretaría de Ambiente y Desarrollo Sustentable de la Nación
National organisations
Instituto Nacional de Tecnología Agropecuaria (INTA)

Additional impact

In addition to the expected impact, VIVACE has a high potential to exceed the initial projections about the impact, as is briefly summarised below.

Advancement of scientific state of the art

Even if VIVACE has been a supporting action and hence no research activities were included, some outcomes of VIVACE have a high potential of advancing the research state of the art.

VIVACE has applied several components for integrated planning which resulted in an innovative framework for sustainability assessment in peri-urban water management. This work has been submitted to the 2nd Water Research Conference, which is one of the leading water research conferences organised by the ELSEVIER that publishes the high ranking Water Research Journal. Out of around 800 submissions only around 35 have been accepted for oral presentations, one of them being VIVACE.

VIVACE pursued insofar innovative technologies, as it integrated the concept of reuse and recycling into water management. This was also recognized by the scientific community, resulting in the publication of a paper in the peer reviewed open access and SCI indexed journal Water 4/2012. Moreover, the high international relevance of this work is documented by the fact, that VIVACE results have been submitted twice to the renowned Stockholm Water Week, in 2011 and 2012, and both submissions have been accepted for presentation.

Figure 23: Presentation of VIVACE results during Stockholm World Water Week 2012

Further, a paper about the main results of VIVACE "Integrated planning for peri-urban water supply and sanitation provision: two case studies from Mexico City and Buenos Aires" has been accepted after peer review for publication and oral presentation at the Latin American Water Week in Chile (Vina del Mar) in March 2013. For this event around 100 submissions were received and 23 papers were accepted for oral presentation.

Finally, the paper that was presented during the Stockholm World Water Week 2012 has been accepted for publication in "On the Water Front", a compilation of the best papers that were presented during the World Water Week, which will be distributed among a large audience of water professionals worldwide.

Wider regional socio-economic impact

The technological studies and recommendations for the management of natural resources in peri-urban areas developed by VIVACE have attracted strong interest among local stakeholders.

In Argentina VIVACE promoted already the implementation of a pilot project that consists in the installation of a water purification plant in a public school in the case study area, supported by AKVO. At present, a second pilot project is beginning in another public school, supported in this case by Coca Cola Company and the World Wildlife Fund. It was possible to develop these projects because of two factors: a. the technological innovations studied by VIVACE, b. the particular interest that local authorities and inhabitants of the islands have developed from their active participation in VIVACE research. These pilot projects allow implementing the results that VIVACE proposed.

The implementation of VIVACE has further attracted the interest of other donors to support the development of research in the study area of the Delta and in general in the coastal areas of the Rio de La Plata. In particular the International Development Research Centre (IDRC) is supporting a project in the coasts of Rio de la Plata that incorporates to VIVACEs issues the analysis of climate change. Also the foundation of the HSBC Bank is interested in improving access to drinking water in towns that do not have this resource in the Tigre Delta. Association with other international organizations and networks related to VIVACEs issues, such as FAN (Freshwater Action Network) and FANAS (FAN network for Latin America) will increase opportunities for implementing the policy recommendations that were developed by VIVACE at the regional level for the management of natural resources in peri-urban areas.

In Mexico this year was election and the new local government will take over towards the end of the year. It is expected that the new government in Xochimilco will continue the interest and enthusiasm showed by the previous local government that participated in VIVACE and that local projects building up on VIVACE will be developed. Further, the Natural Resources Commission (CORENA) of the local government in the case study area has shown strong interest for VIVACE and they are committed to lobby for funds at the Congress of Mexico to implement pilot projects building up on the VIVACE work.

In turn, the implementation of pilot studies in the VIVACE case study areas has a high potential to showcase good examples for peri-urban resource management which then can attract interest among other municipalities in Mexico and Argentina and help to replicate and up-scale the solutions demonstrated by VIVACE. As the section on the economic impact assessment has shown, provision of sustainable water and waste infrastructure substantially contributes to the economic development and hence it can be expected that VIVACE will have wide positive societal implications.

Main dissemination activities and exploitation of results

VIVACE has aimed at the exploitation and dissemination of the project results to various end-users, in particular:

a) local decision makers
b) NGOs
c) users' associations
d) academic and professional community
e) stakeholders and general population

VIVACE has implemented the following dissemination activities:

In both Latin American partner countries (Mexico and Argentina) several local project workshops and seminars were conducted. At the beginning of the project local stakeholders (NGOs, civil society organizations, officials, etc.) were informed about the objectives and scope of the project VIVACE. Various outreach materials (brochures, forms, summaries) were prepared for each specific task (surveys, workshops and focus groups). Local users, user associations, decision makers, academicians, professional associations, professionals and other stakeholders were invited and participated actively at these workshops and seminars. Local partners also provided information on the VIVACE project on their institutional websites in Spanish language. Also a documentary video was prepared at one of the workshops.

Project results have further been disseminated at leading international events such as the Stockholm World Water Week. Further dissemination at important international events will continue after the end of the project. On 22nd November 2012 VIVACE participated at a special dissemination workshop, organised under the FP7 funded WaterDiss 2.0 project as a side event to the IWRM conference in Karlsruhe, Germany. During this workshop a main VIVACE output, namely "Framework for participatory and integrated selection of resource efficient environmental management technologies in rapidly developing urban areas" has been presented. This output was then uploaded on the webpage of the European Water Community and was featured as an "Output Highlight" (see Figure 24 below). Further, work of VIVACE has been presented at the Second Water Research Conference, which took place in Singapore in January 2013.

Finally, VIVACE key results will be presented during the Latin American Water Week in Chile in March 2013 (where a paper of VIVACE was accepted for oral presentation after peer-review) which will allow VIVACE to reach out to a large number of Latin American and international stakeholders.

VIVACE has also been mentioned as a case study in the web-library of the "Evidence-based policy in development Network (http://www.ebpdn.org)". This website is a key outcome of the Civil Society Partnership Programme of the UK based Overseas Development Institute, which is a seven year programme funded by the Department for International Development (DFID) of the Government of UK. It has over 2.000 members from various sectors as can be seen below:

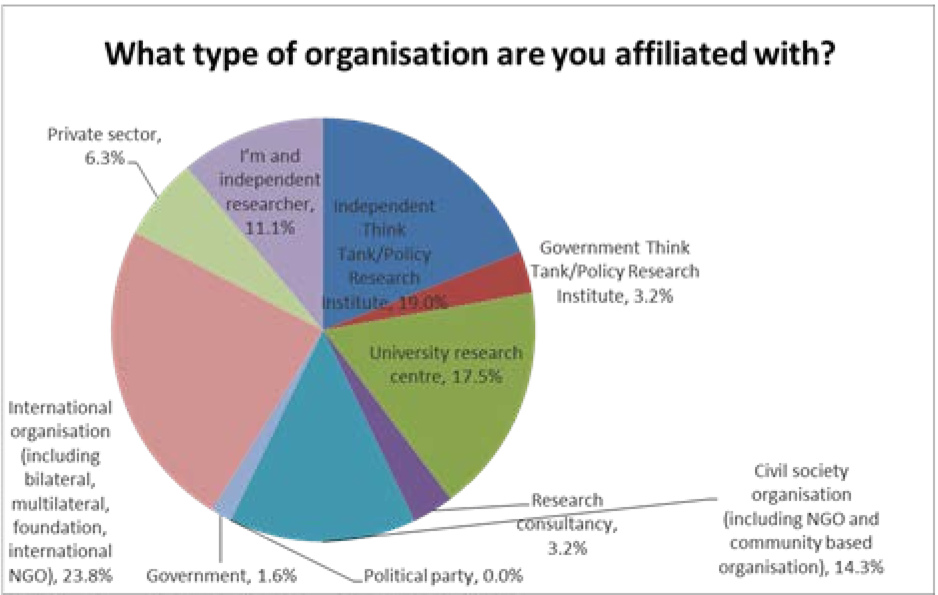


Figure 24: Type of organisations being members in the EBPDN.

A short summary of the project has also been included in the December 2012 *Newsletter of the FP7 project STREAM* that reaches out to about 2.000 professionals in the water sector.

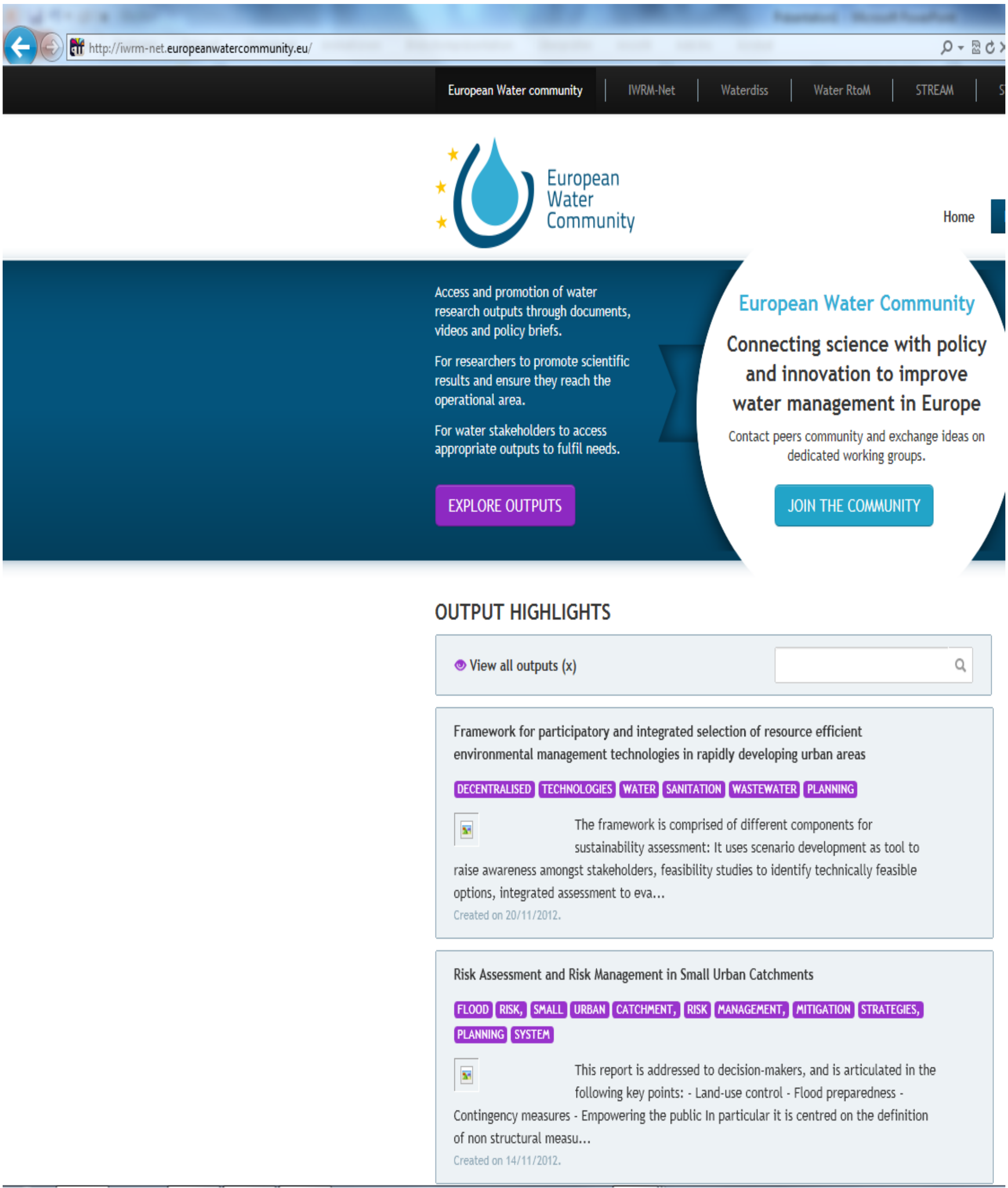


Figure 24: VIVACE output presented as an output highlight on web page of the European Water Community (website copy dated 30th November 2012)

Key results of the VIVACE project have also been published on the VIVACE project web page (see Figure 26&27):

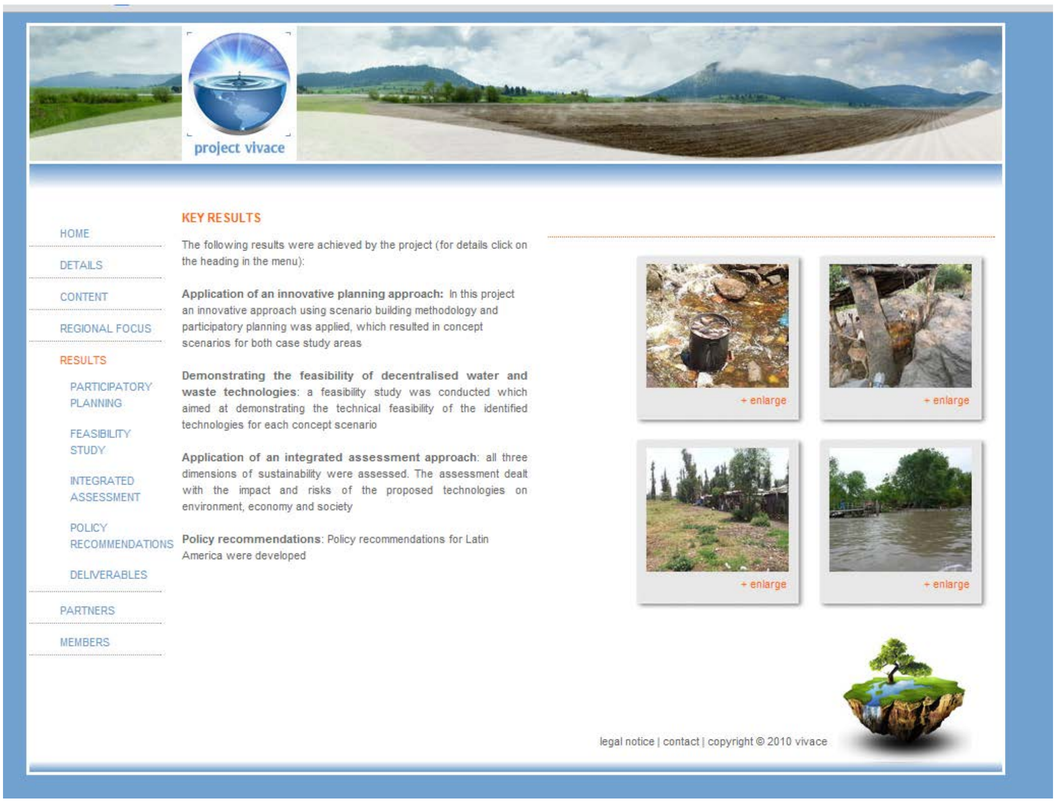


Figure 26: Key project results published at VIVACE web page

Figure 27: Key project results published at VIVACE web page

Publications are also an important part of the dissemination and exploitation of the projects results and so far several publications have already been published or accepted (see section “Use and dissemination of foreground for details”).

In addition to those dissemination measures the VIVACE project has produced several exploitable products such as:

- Production data that contribute to the development of new technologies for better management of natural resources in the case study areas.
- Identification of tools / strategies that should be considered to achieve sustainable social management of natural resources.
- Development of a portfolio of technologies appropriate to the needs and characteristics of peri-urban areas.
- Identification of tools and methodologies that can be used in development projects, with the social participation and technology adoption in first place.
- Design of policy brief and recommendations to improve water and natural resources management in the case study region and in others peri-urban zones.
- The base line study and the technological option has been view as real option to an important academic sector and the local agriculture and also for local residents

For a full list of dissemination activities please refer to the part “Use and dissemination of foreground”.

WEBSITE

www.project-vivace.net

CONTACT

Dr. Markus Starkl
University of Natural Resources and Life Sciences Vienna
Gregor Mendel Strasse 33
1180 Vienna
AUSTRIA
Email: markus.starkl@boku.ac.at