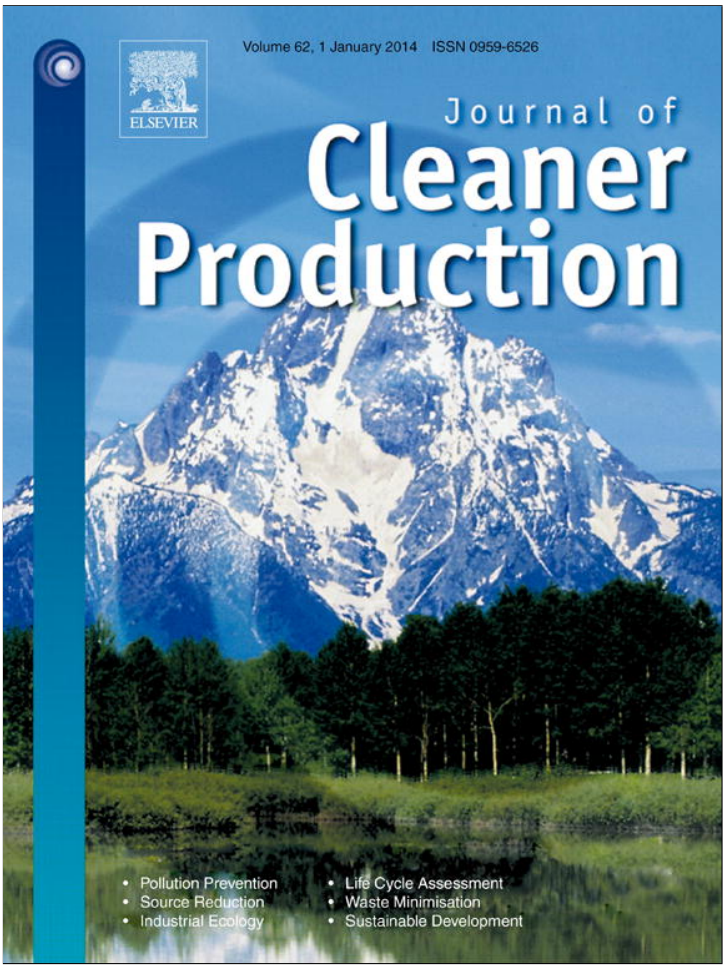

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Water conservation as a tool to support sustainable practices in a Brazilian public university

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ABSTRACT

Rational use of water can be a powerful tool to promote sustainability on university campuses. Other than resource and financial savings, it aims to support technological and behavior innovation towards a more balanced relationship between human activities and nature. This work reports on a water saving program case study, led by a research group at a university in the northeast of Brazil. It describes and discusses methods used and results obtained. From 1999 to 2008 the program reduced per capita water use by half at the university. It has brought significant resource savings to the institution. Internal results foster the implementation of cooperative projects between the university and public and private partners. All these projects involve engineers, social workers and undergraduate students from different courses. However, internal and external results have been insufficient to guarantee the internalization of the program in routine activities of the university. The permanence of the program still depends on the research group that created and manages it. The paper also presents the difficulties faced in sustaining a program like this at a Brazilian university and discusses future action to be taken to achieve the program's goals.

1. Introduction

Sustainability is a long term and complex goal. Universities have an important role in this process, both in terms of technological and behavioral innovation, and have been required to assume it. Technical literature reviews several experiences to seek sustainability in universities around the globe, describing a variety of administrative structures and practices (Disterheft et al., 2012; Corcoran and Koshi, 2010; Davidson et al., 2010; Ryan et al., 2010; Juárez-Nàjera, 2010; Stephens and Graham, 2010; Macnamara, 2010; Ferrer-Balas et al., 2008; Sammalisto and Lindhqvist, 2008; Beringer, 2007; Beringer et al., 2007; Blottnitz, 2006; Tauchen and Brandli, 2006; Verbitskaya et al., 2002). Launching sustainability initiatives requires the implementation of short term activities with rapid and noticeable results. This work reports the case of AGUAPURA, the water saving program of the Federal University of Bahia, Brazil (UFBA).

UFBA, located in Salvador, the capital city of the state of Bahia, in the northeast of the country is linked to Brazil's Ministry of Education. Although in a humid area, with almost 2000 mm/year of rainfall, the city is mainly supplied by water from the semiarid region of the state (which receives less than 800 mm/year of rainfall). Currently UFBA has an academic population of about 35.000 people. The campuses in Salvador included in the program consist of about 100 buildings, with almost all of them having an individual water meter.

AGUAPURA started as an initiative of a group of lecturers at the Polytechnic School of the university. Initially aimed to organize and orientate maintenance activities, it soon became clear that knowledge of each building's daily consumption and awareness of the academic community was central to a more rational use of water. The research group on clean technologies TECLIM, assumed the responsibility to develop a decentralized control system involving students and staff from all academic faculties to support these efforts.

Many university researchers work with environmental issues, but they are predominantly limited to research and lecture rooms. They do not integrate university priorities and operational practices. There was no institutional environment to start a broad environmental program at the university. Hence, a water saving

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program was launched and managed by a research group as a research program. More than just saving water, it aimed to contribute to students' education and to provoke the university to incorporate sustainability actions. Despite the significant results achieved, the program faces continuing difficulties maintaining and expanding its activities, mainly because it has not been fully incorporated into the administrative routines of the university and the institution has no managerial routines which focus on environmental goals.

Chapter 2 reviews some of these approaches and experiences found in literature, referring both to implementation of sustainability programs and water saving efforts at Higher Education Institutions (HEIs), to allow a better comprehension of how AGUAPURA relates to similar programs around the world. The program itself is depicted in chapter 3. As water saving actions and research is an ongoing effort of the TECLIM research group, initial hypothesis and strategies are continually reviewed as positive results and difficulties to overcome, are clarified. This chapter includes a presentation of the main factors identified to be decisive to attain a more rational use of water in universities and other public premises. Chapter 3 also includes a brief description of the set of actions developed to act on these factors. Until now, the program has not been able to effectively intervene on all these factors, nevertheless, significant results have been obtained.

The experience developed in the university attracted the interests of other public institutions, allowing the program to expand its frontiers out of the campuses. Chapter 4 brings a synthesis of these new partnerships. Chapter 5 presents a discussion of the experience developed and the conclusions of this work. The possibility of a specific water saving program to support broader environmental efforts is also discussed here, as well as the barriers that need to be overcome.

2. Environmental practices and water conservation in higher education institutions

Universities have been required to assume a leadership role towards sustainable development. Several international declarations, signed by Higher Education Institutions (HEIs), show the amplitude of the commitment. As well as providing good environmental education and research opportunities, universities should also be an example of what they teach. They should include good environmental practices in all courses, expand environmental issues in society as a whole and underpin a general move towards sustainability (Halifax Declaration, 1991; Talloires Declaration, 1990; Tbilisi Declaration, 1977).

HEIs around the world deliver millions of graduates to the work force each year. Among them there are both environmental specialists, as well as professionals with a strong possibility to generate environmental impacts. Campuses themselves may generate significant environmental impacts as a result of their activities and operations (Alshuwaikhat and Abubakar, 2008; Bonnet et al., 2002; Viebahn, 2002).

Lack of consideration or lack of awareness of environmental issues in HEIs is contradictory to education and recognition of the role of such institutions by society. Both theoretical learning and the incorporation of new patterns of behavior to reduce stress on the environment are more effective if developed in an environment where what is taught is what is practiced (Bonnet et al., 2002; Viebahn, 2002). Moreover, practices of sustainability on campus can boost cooperative research with industry and governmental partners. (Adomssent, 2011; Lehmann et al., 2009). Lack of sustainable practices transmits a message to society that universities do not value and are not able to implement sustainability (Bekessy et al., 2007).

Research on official university internet sites shows that some universities refer to sustainability as essential for social responsibility, academic excellence in learning and research, institutional valorizations and recognition and a trend in growth and qualification towards sustained academic leadership. There are explicit references to the commitment to "do what we say" (University of Cardiff, 2012; University of Lund, 2012; University of Gothenburg, 2012) and the university as a "living laboratory of environmental issues" (University of British Columbia, 2012; University of Harvard, 2012). The "Lünenburg Approach" (Adomssent et al., 2008) is especially highlighted by the emphasis on incorporating sustainability at all levels of training (Beringer, 2007; Barth, 2008).

Despite the fact that sustainability is relevant for society in many aspects, only a few universities worldwide are facing the challenge to strive for it (Adomssent et al., 2008) and to implementing a holistic institutional change (Thompson and Green, 2005; Barth, 2013). However, subscription to statements does not ensure compliance. Several universities did this but do not necessarily seek to fulfill their goals (Bekessy et al., 2007; Wright, 2002). Predominant focus in literature reviewed, is on campus operation: materials, water and energy saving and waste disposal (Alshuwaikhat and Abubakar, 2008).

There are several difficulties in introducing changes in complex institutions such as HEIs. Universities function in non-hierarchical ways giving a high degree of individual freedom to their researchers and lecturers. This makes it difficult to guide the implementation of new practices. Some barriers towards sustainability include: lack of knowledge and interest on the part of the academic community and usually their upper management; short time available for academics; staff resistance to new attitudes and procedures and; lack of pressure from society (Karatzoglou, 2011; Ferrer-Balas et al., 2008; Thompson and Green, 2005; Viebahn, 2002).

Considering this predicted resistance and difficulties, incremental changes may reduce conflicts related to wider changes due to a centralized decision. Each incremental step should be accompanied by communication and participation of the academic community some specific greening actions may deliver rapid and visible results that contribute to the success of other steps (Lozano, 2006). Daily operations change and new routines incorporate sustainable principles as "business-as-usual" (Barth, 2013).

Actions of individuals and small groups may help induce the process. This includes addition of new partners and widening the scope of action. This is accomplished by leading by example, provocations and results achieved (Davidson et al., 2010; Ferrer-Balas et al., 2008). When there is no strong administrative leadership on the subject, the process may involve a relatively small group that has to work with a variable support group, depending on the number of partners it can find for each action. In this case, it is important to identify means to involve the administration in a sustainability agenda, step by step, building political capital by creating programs and projects which include other members of the academic community (Thompson and Green, 2005). Implementation of sustainability into universities is a learning process. There are many ways to initiate it. Barth (2013) suggests the importance to strengthen partnerships and to gradually expand what has already been achieved.

Restricted sustainability actions also predominate at Brazilian HEIs. Publications mostly register isolated water or energy saving and waste management projects. Very few universities express an environmental policy or perform broad environmental management systems. Environmental issues are predominantly limited to research and specific courses or disciplines. Various authors (Karatzoglou, 2011; Ferrer-Balas et al., 2008; Thompson and Green,

2005; Viebahn, 2002) recognize that in HEIs, other priorities and traditional academic work, leave no time for the insertion of cleaner practices.

Bonnet et al. (2002) describe the application of a method for water and energy auditing in HEIs, tested at the University of Bordeaux campus. This method, based on the Eurocampus European Collaboration project, included: upper management commitment, use of internal abilities, involving students in the auditing activities considering their areas of research and consideration of all accounted flows on the campus. The main difficulties identified by these authors were the lack of proper measuring and the wide variety of activities performed in the buildings. Substantial consumption differences were found between similar units and activities. They found that research and development (R&D) activities were the most water and energy demanding.

The wide differences reported in the Bordeaux research confirm results found in other experiences. Authors report that water and energy consumption data obtained from research at 14 universities in 7 countries of the Ecocampus collaboration project showed large discrepancies due to characteristics related to different countries, institutions and facilities.

Mendes (2006) presents information on water consumption at 6 universities in Brazil and 5 in the United States. Among the Brazilian universities, only one, the University of São Paulo, the most prestigious in the country, informs its per capita consumption (70 L/person day). Among the American universities consumption records only data for Stanford University and the University of Virginia (558 and 209 L/person day, respectively) were published. The University of Brasilia's internet site reports that in a 16 year effort, a 73% reduction was achieved. Current per capita water consumption is 21 L/person day (UNB, 2012).

Such a wide variation in per capita consumption highlights the difficulty in comparing these numbers. Significant differences between these universities may explain this variation in consumption patterns. However, these are not readily available. Multiple activities are developed on campuses: teaching, research, catering, housing, sports and gardening. They may include large irrigated areas, including farming activities and sport centers with large fields. Consumption is influenced by each of these activities and total consumption depends on their relative magnitude and, above all, on the level of water waste and losses.

Also in R&D, which, according to Bonnet et al. (2002) and Mendes (2006), has the most intensive use of water and energy, there are large differences due to the sizes and types of laboratories and experiments. Any comparison depends on a detailed knowledge of each institution, their activities and the existence of adequate indicators. The differences in the values obtained make reliable comparisons very difficult. Published data mainly refers to absolute water consumption and reductions obtained at a specific institution. For this reason, in this paper, quantitative results obtained by Aguapura, could not be compared to other results.

The apparent efficiency of water consumption reduction programs carried out at Brazilian universities may indicate a widespread previous situation of high levels of consumption. Lack of proper monitoring and control and poor maintenance practices are determining factors for this.

3. Water conservation program at the federal university of BAHIA – AGUAPURA

The program has been developed since 2001 by TECLIM, the Clean Technology research group at the school of engineering with no external funding. Simultaneously TECLIM has developed water savings projects in intensive water consuming industrial plants. The industrial projects received funding from industry and national research agencies allowing the group to organize a technical and administrative team capable to support Aguapura's operations and computational demands.

Although environmental issues are considered in a large variety of undergraduate and graduate courses and research programs, very few initiatives linked academic environmental activities to the campuses administration and life. There has not been an institutional atmosphere leading to the implementation of a comprehensive environmental management system at the university.

Given these conditions, TECLIM's professors started an intervention as a research and academic extension program with the expectation that results could lead to its insertion into the university's routine. The strategy was to start with what was possible and gradually expand the actions according to the possibilities.

As a precise monitoring of water consumption was not in place, it was assumed that there was a high level of waste and leakages. Without a strong commitment from the university's higher administration, and depending on funds from other projects, the program started with just a team of four plumbers. There was not, at that time, a consistent basis for establishing quantitative targets or administrative support to adopt rigorous planning, tracking and assessment actions (as STARS, AISHE or SMART propose). The initial goal was to prove that a significant water consumption reduction could be achieved leading to substantial economic savings.

Results achieved during these 12 years of activities, proved the initial assumption to be correct. They included a significant water consumption reduction, training of students of various courses, raising a network of voluntary collaborators across the academic units and the development of cooperative projects with external institutions. Broader actions have only recently begun to be incorporated by the central administration of the university.

3.1. Factors identified to affect water consumption in universities buildings

During the program's development, a number of factors where confirmed as important to define water consumption in public buildings. These are indicated in the figure in Appendix 1. Understanding the way these factors occur supports the development of proper action.

Knowing the consumption practiced by the institution and each of its units is a significantly important factor that influences how water is consumed. As all the community members take part in water consuming actions, this knowledge has to be widely spread to allow a move towards more responsible attitudes. Controlling water consumption depends on having access to this knowledge and is mainly a voluntary attitude. The more decentralized and closer to the user the water metering devices are, the better the control can be, allowing better information to users about the consequences of their actions.

A second factor that is a relatively subjective debate, that needs to be addressed, is what here has been denominated as "legitimate demand". This is the water required to satisfy basic needs as well as conscious desires of the user. It is widely accepted that washing hands before lunch is important to maintain good health conditions. This illustrates a basic need. However, individuals may feel the need to wash hands more than 5 times during working ours, as this makes them feel more comfortable. If this consumption decision is consciously taken, it cannot be considered as waste, as it satisfies a user's desire. However, it is a wasteful attitude, for example, to keep water running from the tap while brushing teeth. The amount of water wasted depends on the user's attitude as well as the hydraulic or sanitary device used. These attitudes, considered as the third factor, may be improved by means of information spreading as well as choosing water

saving devices. Where applicable, water charges, may strongly influence waste reduction.

The fourth factor consists on the quality of the hydraulic and sanitation piping system and its maintenance. Good quality devices and maintenance lead to less water losses. This factor does not depend on the users, but on institutional decisions and capabilities. The fifth factor refers to the environmental quality of the building and how environmental friendly it is. Here are considered the existence of rain water harvesting devices, gray water reuse, low water consuming gardening and landscaping and other solutions. Water consumption in some situations may depend on few users, such as in labs and restaurant kitchens. In others, such as toilets, they will depend on a wider and less defined population. The closer the information goes to each user, the more effective consumption control tends to be. A higher level of environmental consciousness will support more rational attitudes.

The program worked with the hypothesis that by building up a collective knowledge on how water was being wasted and lost, and the financial costs due to this condition, a more sustainable behavior could be fostered among the academic community. Moreover, initial earnings obtained by a stricter water consumption control will be able to support the implementation of more effective maintenance work and the gradual substitution of hydraulic devices for more economic ones. Stepwise, environmental friendly construction patterns could be adopted for new buildings and in refurbishing existing ones.

To sustain this process, water consumption control should be publicized as much as possible. Instead of centralized closed control systems, the program prioritized the development of a public control system using the Internet and widespread disclosure of information. Undergraduate students take an important part in this process by encouraging staff of the various buildings to feed daily water consumption data into the control system and interacting with them to understand how water was being consumed, wasted or lost.

3.2. Actions developed

The following actions where gradually implemented as institutional conditions allowed for:

3.2.1. Improved water consumption control by daily monitoring

From 2001 to 2004 consumption monitoring was poorly performed using monthly data from the water bills. In 2004 an internet based site dedicated to receiving data from each of the buildings' water meters began to be developed and implemented. Gradually water consumption monitoring became a daily activity for each of the 90 university buildings. The data was instantly processed and expressed as histograms.

Today, the system, which can be visited at http://teclim.ufba.br/aguapura, provides easy access to several functions, such as data insertion, on line daily and monthly water consumption, wide spread disclosure of information, communication between unit teams, supervisors and program coordination, installation and maintenance operations recordings, historic consumption, on-line training for users of the system, level of participation of all units in terms of data insertion and others (TECLIM, 2012a,b). Figs. 1 and 2 show the graphical interface that presents daily and monthly histograms of one of the University buildings.

An official at each building, indicated by the unit's director, was made responsible for inserting in the system the water meter reading every day at the same hour. After inserting the daily data, a screen is displayed showing the histogram. This provides an instant view of the unit's consumption so that any wrong insertion or a big leakage event can be rapidly identified at unit level. Manual data insertion is intentional. It forces the unit to perform consumption information insertion at least once a day. It also enables the program organizers to visualize the units participation.

Data is supervised and interpreted by a group of students. These are recruited among low income students who receive a scholarship to help them to pursue their academic career. They act as links and supervisors, each one responsible for a number of units, requiring regularity in data insertion from the units and the interpretation of any significant events. The system allows observations to be posted by either, the official responsible for a unit, or his/her student supervisor.

3.2.2. Preventive screening and leak correction

Two teams of plumbers (each including a plumber and an assistant) were mobilized to perform preventive and corrective work. These included programmed checking and regular tests to identify

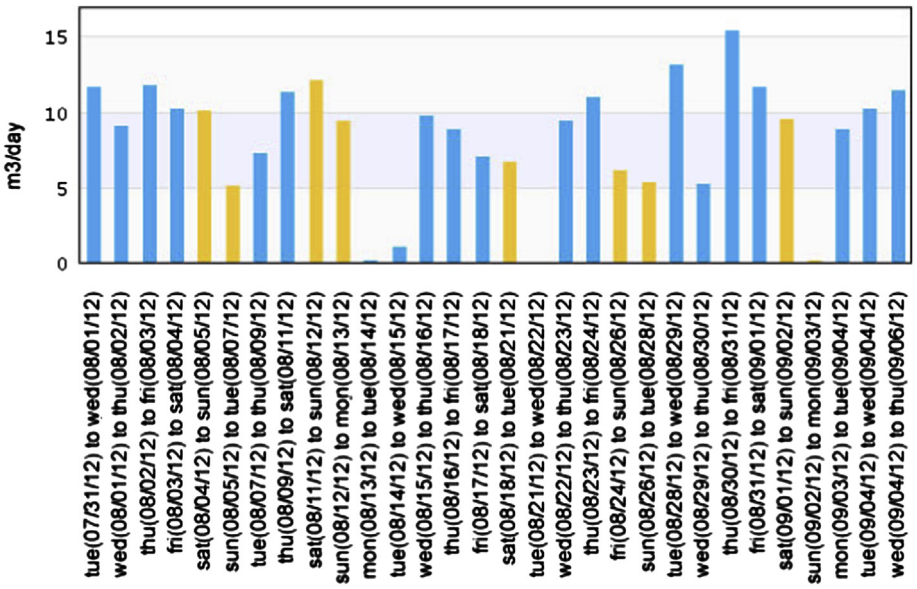

Fig .1. Daily water consumption in m^3/day as shown on the site (clear bars denote consumption on weekends).

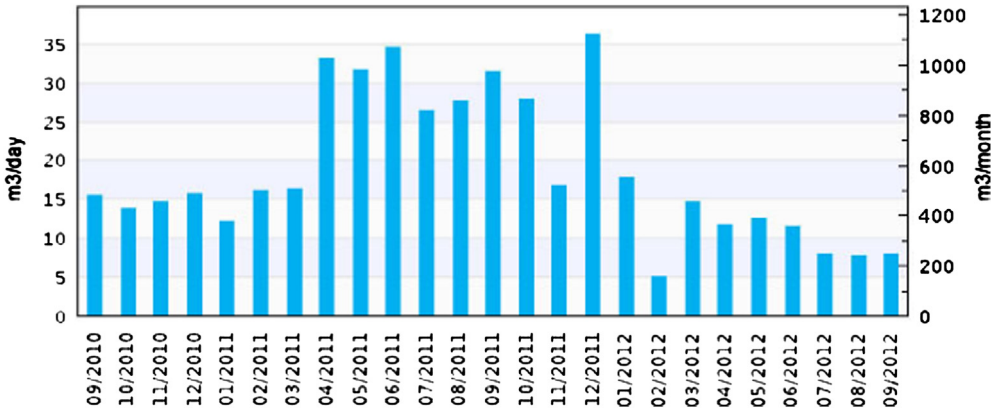

Fig. 2. Monthly consumption in m^3/day.

leaks using defined procedures. As these leaks could be running for years they would not appear as consumption changes and therefore, would not be easily detected by the monitoring system. Maintenance teams were also mobilized for any abnormal consumption identified by the unit operator or the student supervisors. The plumbers work included the substitution of about 200 conventional toilets for 6 L per flush toilets.

3.2.3. Electronic cadastre

Lack of updated technical information concerning the university premises and installations is very common at the university. To overcome this difficulty an electronic registering system was built in the site. The field teams using information collected during maintenance operations fill in this register.

3.2.4. Mobilization of the unit teams and communication

Periodic meetings with the unit staff involved with the program have been organized. These were more necessary during the first two years of the program. As the system became more familiar to the unit representatives these mobilizations became less frequent. As the information system is fully disclosed in the electronic site, it may be easily accessed by the academic community through the university's home page. Highlights are posted on the university's electronic journal.

3.2.5. Undergraduate research and publications

Students from different courses, although mainly from engineering, who act as supervisors, are encouraged to produce scientific work related to their experience in the program. As a result, several publications have been presented in the university's yearly student research seminar. A range of subjects including, operational activities, technical difficulties, unexpected results and behavioral and administrative barriers, have been reported in these events and publicly discussed. Contributions received are incorporated to the program when possible.

3.3. Program outputs and results

As the variables affecting the program's objectives could not be effectively controlled, the coordinators not established quantitative targets. The program started very small, and has been gradually expanding taking advantage of institutional opportunities that occasionally opened. Nevertheless a substantial reduction in water consumption has been achieved. The number of academic units, students and staff from various areas gradually grew and the program became better known in the university. The program's team experience allowed the development of cooperative projects outside the university.

3.3.1. Water use reduction

To present the obtained water use reduction, recent data was compared to the average water consumption and academic population (students, faculty and staff) of 1999 and 2000.

A 26% reduction in water consumption was achieved during the "maintenance stage" from 2001 to 2004, despite the very small field team and precarious monthly measurements (34,600–25,700 m^3/month – annual monthly average). From 2004 to 2008, consumption was further reduced from 25,700 to 21,400 m^3/month, namely an additional reduction of 12%, totaling 38% in relation to the 1999/2000 references.

However, from 1999/2000 to 2008 the university experienced a population increase from about 25 to 30 thousand persons. Per capita consumption, therefore, fell by 49.5% (Table 1).

In 2009, a national ambitious expansion program was launched in Brazil's federal higher education system. Many buildings have been and are being built or refurbished. UFBA's academic

Table 1
Consumption variation from 1999/2000 to 2011.

Year	Academic population (faculty + students + staff)	Water Consumption (m^3/month) (annual average)	Per capita consumption (liters/person.day)	Reduction compared to 1999/2000 (%)
1999/2000	24,738	34,600	46.6	–
2004	26,860	25,700	31.9	31.7
2008	30,272	21,400	23.6	49.5
2011	33,500	26,900	26.8	42.6

Considering that between 1999 and 2011 both, water tariffs and the university population, increased, financial savings provoked by per capita reduction of water consumption were very significant. Having per capita patterns of 1999 been maintained, the university's annual water bill of 2011 would have been US$ 2.1 million higher. This value represents 6.4% of all maintenance costs of the university for 2011. Per capita consumption patterns of 1999 would have produced an increase in water bills of US$ 12.4 million from 2001 to 2011.

population has increased by 11% and will continue to grow in the years to come. During this growth an increase in water consumption from 21,400 to 26,900 m^3/month has been verified. Insufficient water control on the construction sites has significantly contributed to this. Consumption by the construction sites was not monitored or controlled because the building contracts did not required that water should be measured.

Despite the expansion process, total water consumption in 2011 remained 22% below the baseline reference of 1999/2000. Per capita consumption in 2011 was 26.8 l/person.day, which represents 42.6% of the initial reference value (see Table 1).

It is worth noting that the participation of the university units is still voluntary. Only 42% of them actively participate, recording daily consumption and taking rapid corrective actions. Another 50% participate irregularly and 8% do not participate at all.

3.3.2. Academic community and institutional involvement

Incorporation of the project goals and principles of rational use of natural resources by the operating structure of the university has yet to be achieved. The project remains dependent on the research program that created it. It is TECLIM's structure that provides administrative support, manages the teams and the monitoring of consumption and raises external funds. The university administration contributes with the field staff, a supervisor and four workers, materials and equipment replacement. It also provides scholarships for students. Nevertheless, TECLIM is obliged to present a project proposal to compete for funding every year.

The fact that the program has not been incorporated by the university's operational structure implies that an ongoing effort for its maintenance has to be made. Moreover, this has delayed the implementation of more advanced actions such as rain water harvesting, water reuse and exploitation of the local aquifer for non-potable uses. More environmental actions could have been achieved, including other resource saving advances.

As the program has not been made mandatory for the units, a reduction in the participation of academic units has occurred. In 2009, 42% of the units kept a regular daily record of the water consumption measurements. Of these, 50% did not do it on a regular daily basis and 8% did not record them at all. In 2011these numbers changed to 38, 16 and 46% respectively. In the more involved units which were strongly committed to the project, the reduction in participation was considerably lower (from 42 to 38%). However, in those less committed units, who have been demanding greater action from the supervision team, the reduction in participation has been very large (46% ceased to record the measurements of daily consumption). This means that voluntary motivation cannot be the only stimulus for these kinds of initiatives and that it is necessary that actions to reduce consumption be incorporated into routine maintenance practices.

Despite this, some advances are beginning to show. In 2010 the university elected a new principal that publicly declared the commitment of the new administration to sustainability. An Environment Coordination was created in 2012 and has started some new environmental projects.

4. Expansion of the program outside the university

The water rationalization experience developed at the university is being applied in administrative and commercial buildings in Salvador, the capital of Bahia. These include the premises of the Bahia State government, public schools, public hospitals, the city's international airport and a commercial mall. All these projects involve engineers, social workers and undergraduate students from different courses. Financial resources from research partners and official research funds have enabled the allocation of bigger teams than those used at the university. The initiatives at the airport and at a commercial mall have been published elsewhere (Kiperstok et al., 2011; TECLIM,2011). Financial resources for these actions were obtained through national research tenders oriented to foster research on water consumption reduction from the Brazilian Research Council (CNPq).

4.1. Administrative premises of the Bahia state government

The State Government of Bahia established a program to increase the efficiency of public spending. Within this perspective, TECLIM presented a proposal to reduce water and electricity consumption in governmental buildings. This project has been developed under a contract with the State Government of Bahia, including Government departments and other public agencies. The procedures and routines developed and used in the university were expanded to include energy consumption reduction.

Water consumption reduction obtained has varied from premises to premises, depending on the leadership, commitment and participation of staff. Despite being mandatory, involvement with the project varies from enthusiastic participation to neglectful attitudes. Overall consumption reduction over a two year period, was about 33%, resulting in a reduction in expenditure of U$ 1 million without significant financial investments apart from training and monitoring activities.

The three agencies that performed the best achieved water use reductions of 82%, 72% and 55% respectively in this period of time. These achievements were made possible because actions planned, were effectively introduced, and equipment and installations improved. Other agencies only partially implemented the project directives and therefore, achieved more timid results. Large reductions achieved can also be explained by the rapid identification of existing leaks, and improvement of correction procedures. Water consumption related to improper irrigation of turf areas were also controlled (TECLIM, 2012c).

The possibility of large energy and water consumption reductions evidenced by the project led the State Governor to sign an act establishing a program for the rational use of water and energy in the state's public premises. The contract between the university and State Government was recently renewed for another two years to include public schools, hospitals and other public premises.

More detailed research work was developed on the premises of one public company. This work was possible because an engineer at this company was involved in his master's research project (Santos, 2010; Kiperstok and Garcia, 2011).

For about two years water consumption on these premises was monitored, and different actions were taken by the engineer/student. Four different patterns of consumption were identified in this work as can be seen in Fig. 3. During the first phase, daily water consumption was monitored, without involving the building maintenance team. In the second phase, this team was trained and was responsible for feeding daily data into the Aguapura monitoring system. With this monitoring system in operation hydro sanitary equipment was replaced and water saving equipment was installed (consumption pattern 3). In the fourth phase, the maintenance team was replaced as a result of a decision unrelated to the study, thus losing the monitoring methodology and maintenance action-oriented team that developed it earlier. The consumption resumed its erratic behavior, initiating a growth phase. (Kiperstok and Garcia, 2011). This highlights the importance of monitoring and control action. Despite the recent installation of water saving devices, consumption rose again when the control measures where deactivated.

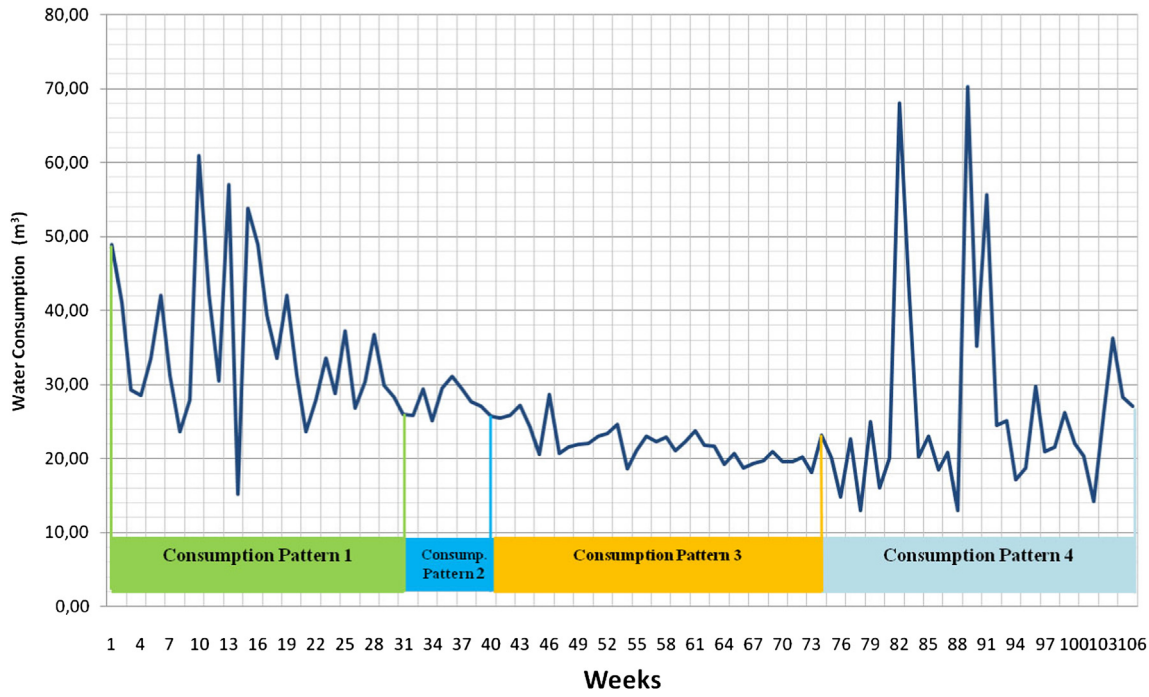

Fig. 3. Monitoring water consumption in a public company building, impact of measures to monitor and control, 2007–2009. Source: (Santos, 2010).

Initiatives involving public schools and hospitals have been started, but are still at their initial stages and results have not been fully analyzed yet.

5. Discussion and conclusions

Rationalization of water use at the Federal University of Bahia project has been successful in three aspects directly depending on its management team: substantial reduction in consumption, participation of students from different courses and development of varied cooperative projects also with student participation. Cost savings are very significant in all actions. At the university, resource savings reached 6.4% of the total operating expenses in 2011. To achieve this, a very low investment was necessary.

On the students training side, the program created a new learning space that allowed dozens of undergraduate and graduate students the opportunity to develop research work on this topic. They worked in groups with researchers, students and staff from different training areas. The program provided access to different aspects of consumption rationalization, from simple physical interventions to behavioral and administrative changes needed to face institutional difficulties. Papers on these topics have been presented in annual seminars or in courses projects. Environmental issues were presented in courses that do not usually address them. The experience generated useful information to facilitate further interventions.

Cooperative projects with external partners brought the issue of reducing the demand for inputs and the feasibility of its implementation in other institutions. An act from the State Government, made it mandatory for public premises to implement procedures leading to the rationalization of natural resources use. The contract with the university has been renewed and new actions are being initiated. Action in public schools has an especially significant potential, including environmental, educational and social aspects, especially for low-income communities.

The project was also successful in supporting further research financing from national development agencies. Financial resources were obtained through national research tenders to reduce water consumption in other institutions such as airports and commercial malls.

However, despite the proven results and internal and external recognition, one may not affirm that the project has been fully incorporated into the university administrative and operational routines. Continuity of work remains dependent on the research program that proposed it. TECLIM's management team is still burdened with administrative efforts, coordination of maintenance teams and consumption monitoring, as well as permanently looking for additional funding.

It has not yet been possible to introduce broader reforms of existing facilities, including adaptations for reuse and use of alternative sources (rain water or ground water). Very little has been achieved in terms of incorporating environmental requirements in construction and expansion of university premises. Difficulties described in technical literature referring to sustainability building in universities, have also been experience by this program, despite the obvious benefits achieved.

Incorporation of the program into the university routines faced an additional difficulty. The shift towards sustainability in Federal University of Bahia, of which the water use rationalization project intends to be an embryo, faced an adverse competition with many other changes.

From 2002 to 2010, university underwent a major expansion and reform process due to internal and external actions. In 2007, an expansion project of the federal public universities was discussed and approved, which began to be implemented in 2009. By 2013 the number of students will have grown about 70% above 2007 numbers. All this has been occurring amid great internal and national political conflicts. Internalization of the new courses, personnel contracting and physical expansion work are still in progress.

An institutional atmosphere of important changes could have been an adequate circumstance to induce sustainability practices in

the university. However, thus far, this did not happen because administrative and academic instances were overwhelmed by new compromises and demands. This situation generated great stress on the university, in academic, administrative and political terms. Considering the diversity of interpretations that prevails on pursuit of sustainability, the insertion of additional challenges was out of the range of capabilities that could be fully adopted by the institution.

Only in March 2012, was the water reduction project officially presented to the University Board as an opportunity generated by the discussion related to the creation of the Coordination of Environment. The higher administration requested TECLIM to pursue a comprehensive water and electricity use rationalization project, which is being finalized.

If this project is accepted the water consumption reduction effort will have fulfilled its role of a precursor action towards the insertion of sustainability practices in the university.

The initial hypothesis, which referred to the significant importance of water consumption knowledge and monitoring, has been proved correct.

Aguapura created conditions for the participation of students and staff from areas that had not previously focused on sustainability. The program created conditions for significant water savings at the university and developed projects with public and private partners which have serious prospects for expansion. Sustainability actions will be officially incorporated in the University's operational practices when the water and electricity rationalization consumption plan, at the moment being finalized, is approved. In this way, Aguapura will have fulfilled a significant role as a precursor on inducing the university to a commitment towards sustainability.

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Appendix

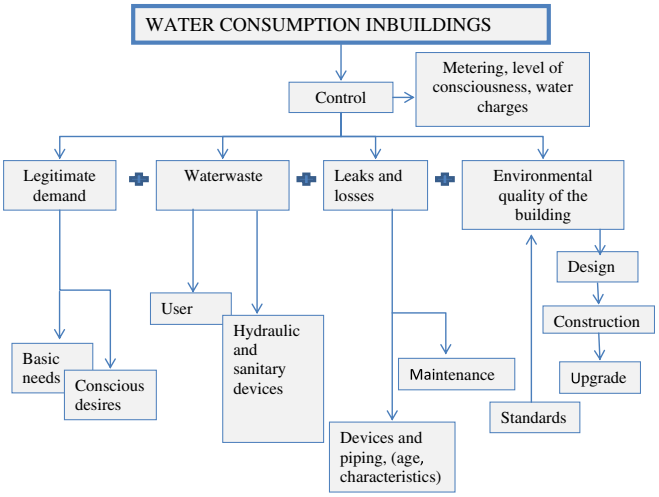

Fig. 4. Main factors that influence water consumption in buildings.

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