RESEARCH AND DEVELOPMENT

IN SUB-SAHARAN AFRICA

UT SCIENTIIS
ILLUMINENTUR GENTES AFRICAE

December, 2006

Ecological development of settlements - the case study Valley View University, Accra, Ghana

Gunther Geller, Wolfgang Berger, Nicola Fries, Jörn Germer, Detlef Glücklich, Gunhild Höner, Seth Laryea, Joachim Sauerborn

1 Introduction

1.1 Initial situation

The Valley View University (VVU) is situated 30 km north of the capital Accra within Ghana's coastal savannah zone. The university campus covers 121 hectares and hosts 1.500 people, most of these students and half accommodated outside. Facing the projected number of about 5.000 people on campus in 2010 the university in co-operation with supporting partners decided to expand the institution based on a holistic ecological concept. Implementation started 2003, financed by the German Ministry of Research and Education (BMBF) within a programme for decentralised water supply and wastewater treatment systems.

Initially at the time of the first visit of VVU in 2001 water was delivered campus by truck. Rainwater harvesting was restricted to a few buildings. Since 2004 about 13 m3 of tap water is supplied daily from the water works in the neighbouring village of Oyibi. The limited water supply was aggravated by lavish use. Conventional water closets with a flushing volume of about 20 litres have been the main toilet type on campus. There was no central sewage system at VVU and wastewater disposal took place in septic tanks decentralised for each building. Domestic refuse was incinerated and buried on-site.

Waste separation and recycling is now in the starting phase. Urine, faeces and wastewater are treated and utilised on campus, bio-waste and leftovers from the kitchen are used by surrounding villagers as animal feed, plastic-bags of drinking water are collected and delivered to a recycling plant.

1.2 Partners

The ecological development of Valley View University is supported by the Bauhaus University Weimar (BUW), responsible for architecture and town-planning, the University of Hohenheim (UHOH), which accounts for agriculture and nutrient cycling at VVU, the Ecological Engineering Society (IÖV), that coordinates the project and is responsible for quality management, and Berger-Biotechnik Ltd. as well as Palutec Ltd., two companies responsible for the sanitary installations and systems inside and outside the buildings. Over the course of the project-time other partners joined, including the universities of Augsburg, Giessen, Magdeburg and Wiesbaden, the Centre for International Migration and Development (CIM) and the NGO Support Africa International (SAI).

2 The Program

2.1 The holistic concept

The holistic concept aims for a long-term sustainable functioning of VVU. Part of the ecological holistic concept is a master plan for the physical development, which shows the final stage with approximately 5.000 people on campus. This master plan is closely linked with the analysis of the mass flows for this stage of expansion and more additional measures in the area of information, organisation and quality management.

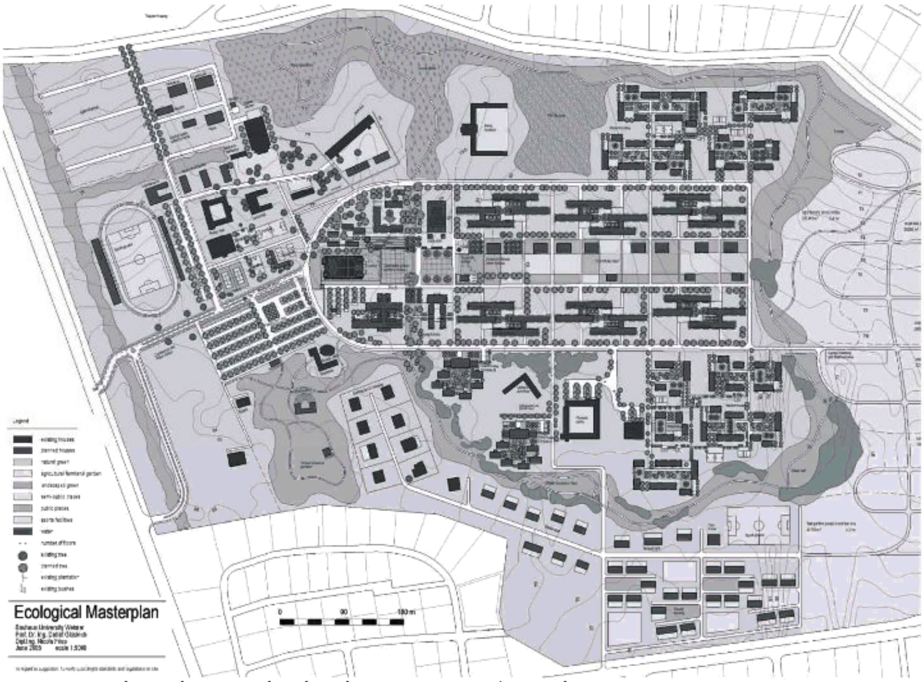

Fig. 2-1: Ecological masterplan (Bauhaus University Weimar)

Fig. 2-2: Tanks for urine at the new sanitary building of the cafeteria

2.2 Physical Measures

Included in the ecological masterplan are also those physical measures, which are part of the BMBF-project. These are buildings like the old main building, a new faculty building, a guesthouse and the cafeteria with the new sanitary building, a women's dormitory etc. These buildings highlight positive examples of installations for treatment and management of black water, grey water and rainwater, urine and biogas. The biogas plant consists of two simple domes connected in line, without any electric mixer.

Ecological sanitation, including dry urinals and water saving separating toilets, is an alternative method of human excreta and domestic wastewater treatment and reuse. The approach seeks to avoid environmental pollution and hygienic hazard through well aligned recycling of nutrients and water contained in sanitary products back into productive agro-ecosystems. The products collected by the ecological sanitary installations are utilised on the VVU own farmland for growing various crops like maize (Zea mays), cashew (Anacardium occidentale), mango (Mangifera indica) etc., showing, that even under the prevailing environmental conditions with scarce rain and poor soils it is possible to produce food, if the available resources are used effectively. Consequently a micro-level study is carried out, to assess the type and quantity of water and organic materials generated at the campus and its present mode of management. This information is employed to identify the appropriate technologies to enhance the value of the material produced and re-use it in agriculture.

2.3 Informational measures

A free flow of information is necessary for the success of any project dealing with sustainability. In the BMBF-project the information goes various ways. These are close personal contacts, a FTP-Server for the internal exchange in the project, the homepages of IÖV (www.ioev.de) and UHOH (www.uni-hohenheim.de/respta), regular meetings of the project-team and a lot of bilateral meetings of the partners in Ghana and Germany. Publications like a booklet about the entire project (Bauhaus University Weimar 2006) and flyers for the various topics are other ways of communication.

2.4 Measures of Quality Management

The long-term function of the installations established in the frame of the BMBF-project is ensured by an encompassing quality management (QM). Acceptance is a crucial point in such a project, therefore all measures which assure that inside and outside the project are essential (for example: information campaigns, info-boards, public relations etc.). Apart from raising awareness concerning the ecological approach, detailed information and education must be provided on various levels, including instructions for workers and craftsmen, along with guidelines and standards for hygienic and environmental safe handling and usage of the sanitary products. Very important is creating permanent posts at VVU (e.g. an ecological director, farm manager, especially trained cleaning staff and caretakers.). In addition to the personnel of the partners two CIM-experts (a master brick layer/construction manager and a landscape architect) provide on-the-spot support for two years. Other measures have been the provision of an office and demonstration building named ecotec-centre for the physical plant department and the project partners.

Fig. 2-3: Intensive discussions with the masterplan group at VVU

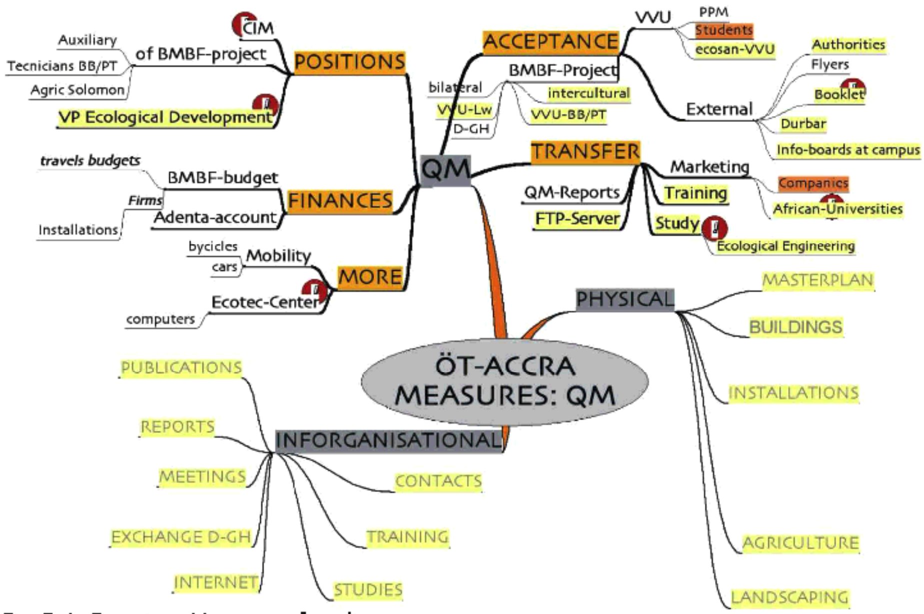

Fig. 2-4: Overview: Measures of quality management

Special care is given to the sociocultural environment and it's implementation in the intercultural communication (see: Gyekye 2002). A graduate school program on ecological engineering, which shall be implemented in the near future, will help to deepen this topic in the organisation of VVU and as a matter of teaching and research.

3 Methods

3.1 Town planning / Architecture

In a first step a mission statement was worked out: "VVU, the First Eco-University of Africa".

Concerning town planning the approach of "Stadtschaft" (literally "townscape") sets the framework for the single concepts. This approach for the first time will be implemented and tested at VVU in a practical case of town planning. The term of landscape, which means a space with cycles and relations between the involved creatures will be applied by "Stadtschaft" for human settlements dominated by human beings. In such a "Stadtschaft" the human influence is dominating, but nevertheless ecological principals are given a special consideration (see: McDonough & Braungart 2003).

The single concepts like water, traffic, open space, energy, buildings and socio-cultural infrastructure are merged into a holistic whole by this approach.

For designing purposes the cell-model is being applied. Cells are entities, similar in their function or their fluxes of matter. For ecological town-planning it is necessary to combine these various and different cells in a synergetic way (see: Glücklich 2006 and Bauhaus-University Weimar 2006).

3.2 Ecological Cycles

For the ecological cycles a model has been developed and implemented which shows the most important streams of water and nutrients between the single cells and between the whole campus and the surrounding environment. In this model, for example agriculture, student hostels and faculty buildings are cells, each of them having a very specific characteristic of mass flow.
The mass flow analysis has been worked out for the initial state (1.000 persons on campus) and for the final stage with 5.000 persons. Various scenarios have been elaborated for this state with various central or decentralised solutions for the mass flow. This allows for adjustment with other requirements in the development of settlements. A lot of analysis is done for the ecological sanitation products in respect of hygiene and nutrients, partly on site, partly at the University of Hohenheim. The various flows of matter are registered better and better in the course of time by the measuring devices installed, by tests of the installations and by interviewing the users.
The feasibility investigation focusing on the ecological sanitary products as a water and nutrient source for agricultural production includes assessment of nutrient content, nutrient efficiency, pathogen control and producer as well as consumer acceptability.

3.3 Agriculture and greens

Within the ecological development of VVU, agriculture is challenged to produce crops for the supply of the cafeteria and the local market, while offering environmentally sound and hygienically safe solutions for valuable and nutrient-rich sewage water, thus closing the nutrient loop. For this purpose, VVU has reserved an area of about 20 hectares for farming on campus. The poor nutrient status and the low water holding capacity of the soil along with little rain make efficient use of resources enhancing soil fertility an absolute must. The division of the farm land into productive sections enables a continuous supply of a variety of produce and at the same time offers a range of options for application of the various sanitary products. For example cultivation of trees enables the productive use of water supplied by intermittent rain and constitutes a persistent sink for urine-based fertiliser and compost. Hence drought resistant tree species, e.g. cashew, mango, starfruit (Averrhoa carambola), guava (Psidium guajava) and oranges (Citrus spp.) were planted and meanwhile occupy the major portion of farm land available on campus. Staple food crops (maize, sorghum (Sorghum bicolor), cassava (Manihot esculenta), cowpea (Vigna unguiculata)) are cultivated in rain-fed field trials during both rainy seasons (March to July and September to October). Urine is employed as fertiliser and compost to improve soil quality. In especially designed fruit orchards, more water-demanding species, e.g. papaya (Carica papaya) and banana (Musa x paradisiaca), are irrigated with grey water and biogas effluent and intercropped with species such as pineapple (Ananas comosus) and passion fruit (Passiflora edulis).
A green corridor, a naturally shaded footpath, will lead around the inner campus offering an area for agricultural and environmental education as well as recreation. Passing through the farming section, the path is dominated by avocado trees (Persea americana) planted in a loose pattern. Sections of the green are used for the demonstrative cultivation of endemic and introduced plant species well adapted to the local environment. Depending on the species, grey water, urine and compost will be used for irrigation and soil amelioration.
The main goal of the agricultural part of the ecological sanitation project is to evaluate and understand the agricultural requirements as well as the necessary technological solutions for cost-effective treatment of human excreta and their environmental friendly use.

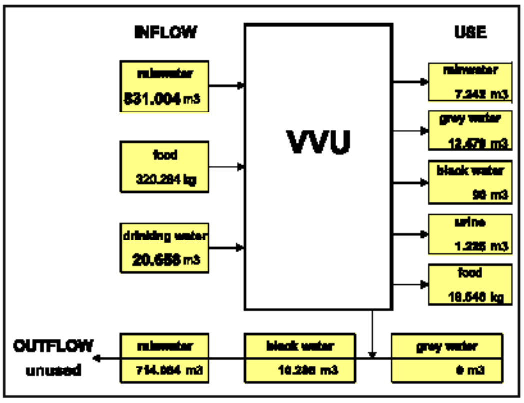

Fig. 3-1: Mass balance of VVU for 5,000 persons on campus

Fig. 3-2: Agricultural trial: Maize fertilised with urine in comparison with different combinations of mineral fertilisers

4 Preliminary results

4.1 Physical measures and ecological cycling

Water saving and separating sanitary installations have been fitted in the existing faculty building and students hostels as well as in the newly erected ones, including the sanitary block at the cafeteria, the new faculty buildings and the guesthouses. Outside the buildings rainwater is collected, purified and stored, black water treated (in septic tanks, sand filter and biogas plant) and grey water and urine are collected and used successfully. Good experiences have been achieved with water saving toilets, dry urinals and grey water collection in their implementation, operation and acceptance.
The evaluation and optimisation of the biogas plant and the rain water installations are still in progress. At the moment there is too much blackwater going to the biogas plant, not enough organic material and this does not contain enough caloric value (e.g. no fat and oil of the cafeteria). Therefore the biogas process does not work very well, also causing a bad reduction of hygienic germs in the runoff. That´s why it and the other blackwater is not utilised yet. Generally however it could be proved that the ecological sanitation products at VVU (urine, urine-water-mixture, grey water) can be applied simply and the acceptance inside and outside of VVU is very high for that.
Preliminary results show that the nutrient content of the collected urine is lower than in comparable studies conducted in Europe. One of the reasons contributing to the found difference in nitrogen content may probably be the lower protein intake as a result of the exclusively vegetarian food served at the cafeteria. The high temperature may contribute to a very fast phosphorous fixation (struvite formation) in the collected urine. This is assumed to be, apart from intake, the cause for the very low phosphorous concentrations measured. Published studies demonstrate that there is a high correlation between potassium intake and excretion in urine. Therefore, similar to nitrogen, the low potassium concentration is possibly primarily related to the alimentation. Nutrient assessment of grey water, black water and compost are not yet concluded.
In a maize field trial that investigates the nutrient efficiency of urine in comparison with manure and mineral fertilisers (Fig. 3.2) it has been shown that the application of sanitary products led to a considerable increase in the production. The results indicate that under the local conditions maize yields can be increased with fertilisation at least 5-fold. No significant difference between the urine and the other nutrient treatments has been found. This suggests that urine can substitute mineral fertilisers without adverse effects on yield.
The advantages of grey water irrigation are impressively demonstrated with the successful

establishment of a banana and papaya orchard as well as an avocado plantation. All of these crops do under natural circumstances not thrive at VVU, but grow very well if grey water supplies water and nutrients. Due to the large quantities produced and applied it became necessary to optimise the grey water transport from the various buildings to the agricultural area. The transport by a tractor drawn trailer will be substituted. An underground pipeline from the women's dormitory to the agricultural site is under construction.
First composting trials to treat septic tank sludge and scum from the cafeteria's fat separator are in progress. A shredder is used to produce structuring material to allow air circulation within the compost pile. This is to enhance the microbiological activity through which the process temperature is increased and maximum temperatures of 60 degrees Celsius are achieved. Further effort will aim to maintain this temperature over a 10-day period for a satisfactory reduction of the pathogen load.
A more precise analysis of the mass flow from single cells in 2006 revealed, that the values for the whole campus are well in accordance with the pre-estimations. For individual cells the case is, however, different. For example the new sanitary block was expected to be the main producer of urine and wastewater, but is less utilised than expected. The reasons are being evaluated. One is most probably the poor caretaking (cleanliness, lack of toilet paper and towels etc.). The general acceptance of the building is also of importance (e.g. from the local point of view it's direct situation near the cafeteria possibly does not guarantee sufficient intimacy). A further problem is the insecure supply of water to the campus and consequently to the water toilets. The plan for the further development of the campus includes therefore additional sanitary blocks with dry toilets.
A crucial question is to find the optimum rate of decentralisation that creates positive synergetic effects between the various cells. Therefore a decision model is under development, which allows for a simple arbitration concerning the various streams of urine, rain water, grey water and black water.

4.2 Information

The success of the physical measures was very much depending on care, training, acceptance and the choice of the special responsible persons. Training, education and briefing of the workers and members of VVU and the very intensive involvement of VVU are of crucial importance. The exchange of information between the project partners in Ghana and on site is also essential. The top ranking given to the activities in the field of information in the BMBF-project has shown a very positive effect and is central for the success of such a project.

Fig. 4-1: First meeting of all Ghanaian and German partners 2004

4.3 Quality Management

One of the compulsory measures of quality management is the inclusion of essential positions for the ecological development into the organisational scheme of VVU. It could be achieved for the cleaning staff and for the most important craftsmen (electrician, plumber). The ecological director acting directly under the president is looked for and interviews with possible persons are in process. By the help of the good contacts with the president of VVU it was possible to change and expand the use of an existing building for the so-called ecotec-centre. This accomodates now the workspace for CIM-experts, the German project partners and the German exchange students, additionally to the members of the physical plant. It proved essential for the long-term success of projects like this to have such a kind of encompassing sustainable quality management.
The experience in our project shows that a qualified supervision of the buildings by a construction manager is essential. This person has to co-operate very closely with all partners. Additionally a person who takes care of the communication of the partners between Ghana and Germany must be on-site at VVU. This person also must take care of the integration of such a project in the local and regional environment (e.g. with developmental organisations like GTZ, state authorities of Ghana and so on). In our project it was possible by the additional two CIM-experts, which could be acquired in the course of the project.
Through the installation of the new sanitary equipment, in the course of continued scrutinies and as a result of an MSc thesis study knowledge on the acceptability by the local population was obtained. Everyone involved in the collection, transportation and use of human wastes shows an initial rejection. With explication, education, creation of team spirit and time objections along with preconceptions can be overcome. The primary attitude towards the handling is different for each quality of waste.

While for urine the collection to the application on the field was easily implemented, the reuse of grey water and composting of septic tank sludge and scum from the cafeteria's fat separator was more difficult. The introduction of all nutrient and water cycles has in all cases greatly facilitated when the workers where not left alone with their new task, but hands on supported by their superiors. A questionnaire survey in the nearby villages revealed that most of the farmers are interested in receiving human urine derived fertiliser on their field. They stated also, that they would be willingly pay for the service.

5 Summary

The unique approach in the ecological development of Valley View University in Accra, Ghana, is that of an encompassing ecological concept where technological and other measures are embedded. Ecological cycles can be established in such a framework successfully. For tropical areas the use of grey water and urine proved as being simple and very helpful. The long-term development of the campus and the long-term success of the technological measures are ensured by an encompassing quality management. This approach has proved to be successful to a large extent. There is a good perspective to use this approach for other ecological developmental areas in town and regional planning, for example in megacities.

Literature
Bauhaus University (Ed.) 2006.
Ecological cycle management at Valley View University in Accra, Ghana. IOEV-Press, Augsburg: 58.
Glücklich, D. (Hrsg.), 2005.
Ökologisches Bauen. Von Grundlagen zum Gesamtkonzept. Deutsche Verlags-Anstalt, München: 246.
Gyekye, K., 2002.
African Cultural Values. An introduction. Sankofa Publishing Company, Accra, Ghana: 194.
McDonough, W., Braungart, M., 2003.
The Hannover Principles. Design for Sustainability. Tenth Anniversary Edition. New York, Hamburg: 101.

Contact address:
Gunther Geller, Project-Coordinator
Ingenieurökologische Vereinigung
(Ecological Engineering Society)(IÖV)
Frohsinnstraße 11
D-86150 Augsburg, Germany
e-mail: info@ioev.de

Gunther Geller, Project-Coordinator