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Publishable Summary

Title: Integrating BOMOSA cage fish farming systems in reservoirs, ponds and temporary water bodies in Eastern Africa

Acronym: BOMOSA

Budget from EC: EUR 1 499 998.00

Name of co-ordinator: Prof. Herwig Waidbacher, Universität für Bodenkultur Wien, Institut für Hydrobiologie und Gewässermanagement, Austria

Project objectives:

The BOMOSA Project will research the **economic viability, social acceptance and necessary institutional environment** of a relatively simple technology that has been proven technically feasible over the last two years. BOMOSA is pioneering small scale fish farming in Eastern Africa by establishing rural aquaculture networks (coordinated in a “hub and plot” system) to economically integrate aquaculture with agriculture. The BOMOSA system will form the basis of a socio-economic model that will contribute to poverty alleviation in Eastern Africa by providing sources of supplementary high protein food and additional income to rural communities in Kenya, Ethiopia and Uganda.

The 36-month project involves four European partners:

- two universities, a science academy and an NGO and
- six African partners: two Kenyan universities and four government-run fisheries research centers from Kenya (2) and one each from Ethiopia and Uganda.

The summarized scientific and technical objectives of the project are:

- Apply a participatory approach to define targets in terms of economic viability and social acceptability at community levels for the new BOMOSA plots.
- Develop and validate an evaluation method using remote sensing to assess and characterize water bodies for use as potential BOMOSA plots.
- Set up fourteen BOMOSA plots and optimize the technology in three types of small (less than 5 ha.) water bodies within four eco-zones across Kenya, Ethiopia and Uganda.
- Evaluate locally available, agricultural by-products and cost-effective processing technologies as a resource for sustainable production of low-protein fish feed.
- Determine requirements and make recommendations for a legal and regulatory framework based on potential veterinary, public health and environmental impacts of BOMOSA.
- Develop capacity building and dissemination material for the local community, relevant authorities and policy makers and the international scientific community.
- Develop a socio-economic model for sustainable introduction and widespread uptake of the BOMOSA scheme in Eastern Africa.

Expected results and outcomes:

The proposed project will focus on **research and capacity building** through cooperation between European and African universities, research centres and academies to:

- **Prove the overall conditions of economic viability**
 - Ensuring nutritional, cost-effective and reliable sources of feed from agricultural by-products within four eco-zones with consideration to seasonal factors
 - Analyze areas offering suitable socio-economic conditions and potential water bodies (both temporary and perennial) through use of remote sensing to determine how the scheme could be implemented in Kenya, Ethiopia and Uganda
 - Determine minimum and ranges of economies of scale in accordance with direct and indirect benefits at community and regional scales

- o Design a micro-financing scheme that would allow rural communities and/or families to set up and sustainably run a BOMOSA plot on an owner/operator basis after the INCO project is completed
- **Examine factors leading to social acceptance**
 - o Implementation of a participatory approach to involve community stakeholders
 - o Consideration of ethical, gender and cultural aspects
 - o Consideration of resource use conflicts on traditional farming methods and other potential “livelihood” effects
 - o Determining current preferences and demands in local and regional markets
 - o Design and apply suitable dissemination measures to promote the benefits of localized fish production, both in terms of human nutrition and additional income
- **Determine the necessary institutional (legal & regulatory) framework**
 - o Not exceeding environmental carrying capacities of water bodies
 - o Consideration of veterinary and public health aspects
 - o Ownership and rights and potential issues of conflict

Towards completion of the project, a Technology Implementation Plan (TIP) will have been established as a synthesis of the research work along with recommendations for policies and an institutional framework necessary for the sustainable implementation of BOMOSA.

Results gained at the end of Period 1:

- A communication plan has been established for efficient information exchange within the project consortium and for communicating the BOMOSA approach and its activities to various stakeholder groups and general public.
- The plot characterisation and selection criteria were discussed and finalised at the kick-off meeting. Site characterisation and selection were further refined in a meeting held in Kenya between the African partners.
- 13 sites in 4 different "eco-zones" were selected in Kenya, Ethiopia and Uganda. The ownership of the selected sites belongs to different stakeholders (community based, school based, private). The nominated members of the plot committees were confirmed by the Steering Committee and they are now fully established. The following regions have been selected for the study area:
 - o Kenya:
 - Semi Arid Region (Machakos Region) 3 sites
 - Highland Region (Mount Kenya Region) 3 sites
 - Lake Floodplain (Lake Victoria Region) 3 sites
 - o Ethiopia:
 - Rift Valley 2 sites
 - o Uganda
 - Lake Floodplain (Lake Chioga Region) 2 sites
- A survey of the economic viability and social acceptance was done to provide an overall picture of the structure and standards of living of the communities and households surrounding the selected water bodies. Baseline development tools for existing and new sites were developed and shared with other partners in Uganda and Ethiopia. The result of this first survey can be described in the way that for the project it is expected to have an economic impact on the rural households and can make a contribution to nutrition, food security and sustainable livelihoods of the rural poor.
- Baseline environmental data from existing BOMOSA plots was analyzed and seasonal variation of water quality parameters was documented. Standardized field and laboratory protocols have been synthesized and distributed to all consortium partners. Data obtained from the first veterinary survey, together with the result of further investigations carried out in Kenya and Uganda, were used to assess presence, prevalence, infection intensity and abundance of parasites in the sites taken into consideration and to evaluate their possible effects on productivity and public health. The first stage of a Remote Sensing based evaluation method was developed to assess potential water bodies.

- The construction of 13 piers for the selected BOMOSA plots has been completed. The construction plan was designed and adopted by the Kenyan partners. Each pier accommodates 10 cages and has 2 cage provisions for holding fingerlings and fish harvest. In Kenya 100 feeders were assembled using locally available material and imported clockworks. Uganda and Ethiopia acquired fully assembled feeders.
- Fingerlings have been reared for stocking and adequate numbers are available for stocking the plots. Several transportation techniques are being tried and include among others constant aeration. In addition, fish are being transported during the night to avoid high temperatures in the transport containers.
- BOMOSA information flyers and posters have been printed and distributed to key-stakeholder groups. Sign-boards have been set-up at the plots and at the main roads. Small promotion articles have been produced and to the stakeholders delivered. A BOMOSA song has been composed. Standardized field and lab protocols have been compiled and provided to all project partners. Besides the various documents, dissemination took also place by means of various local information events (community sensitization meetings, meetings within site selection procedure, community mobilization meetings, plot committee member meetings, capacity building courses for local fish farmers), press conferences, TV interviews (Ethiopia), newspaper articles, specialist press, scientific publications, oral presentations and poster at various congresses and workshops.

Results gained at the end of Period 2:

- Capacity building and dissemination events for the plot communities were arranged in conjunction with BOMOSA events, like sampling, harvesting or restocking. Also during the market-survey and social acceptability study the community members were strongly involved.
- A manual for pathological, parasitological and bacteriological examination of fish was produced, as well as a manual for "GPS and GIS application and processing of satellite images". These manuals were distributed among the involved partners. Several BSc, MSc and PhD thesis treating topics of the BOMOSA project are in progress. One PhD thesis and three MSc theses were already finished within the runtime. BOMOSA posters were prepared and presented at different occasions like scientific workshops, exhibitions or agricultural shows. The BOMOSA flyer was translated in Amharic for the Ethiopian sites and their communities, for the Ugandan project sites it was translated into Lusoga. At the BOMOSA sites sign-posts were installed, presenting the title of the project, the BOMOSA logo, the FP 6 logo, the name of the site and the contact details of the institution responsible for the respective plot. The BOMOSA website is regularly updated with latest news concerning events within the project, activities on the plots and outputs of the project. High-ranked politicians visited several BOMOSA sites. The Austrian president has been to Sebeta, the hub of Ethiopia, a Kenyan parliamentary committee and the Kenyan minister of fisheries visited the site in Harambee. Sagana, the hub of Kenya, was presented to the Ugandan minister of Internal Affairs.
- Different digital image processing methods were developed and used for detecting small water bodies in Kenya, Uganda and Ethiopia. For the development of the digital image processing techniques professional software like ENVI and MultiSpec, a free software, were used. Within the priority regions for BOMOSA up scaling LANDSAT data from Ethiopia and ASTER data from Kenya and Uganda were purchased. Six LANDSAT scene subsets and five ASTER scenes were evaluated, water bodies were identified and maps prepared for all three countries. The produced maps should be used as basis for the Technology Implementation Plan (TIP).
- The second part of the "Remote Sensing Course and Workshop" was held in Ethiopia. Within this workshop the contents of the developed method for evaluating small water bodies were presented to the involved partners. In the practical part the new method was applied on different examples.
- Veterinary monitoring activities were performed in Kenya, Uganda and Ethiopia to evaluate risk factors for the cultured fish. Effects on fish health and public health by recovered parasites were assessed. Recommendations on risk factors influencing the introduction and diffusion of parasites and the outbreak of bacterial diseases have been developed. Furthermore analyses were carried out due to the high mortality rates of fingerlings after the transport from the hub to the plots in July 2008. Bacteriological and parasitological investigations were made to give recommendations on the basis of the results.

- OEAW group reported on the impact of toxic cyanobacteria on fish and the environment. Some algal groups are able to produce toxins (attention was paid to cyanotoxins), which seriously affect human health even via the food chain. Investigations of the first year showed that microcystins occurred regularly in two out of nine ponds. Therefore quantitative samples integrating the whole water column were analyzed in order to determine MC concentrations of the water bodies. Cultures from the microcystin-producing genus *Microcystis* were analyzed and the major aim was to characterize the cyanobacteria that produce microcystin both morphologically and genetically.
- For all three countries (Kenya, Ethiopia, Uganda) locally available feedstuff was analysed on the nutrient contents. In detail are these:
 - Animal sources: Catfish and tilapia remains, Poultry feathers, Freshwater shrimps & Omena fish
 - Plants sources: Banana, Papaya, Cassava, Arrowroot, Sweet potato leaf, Mexican Sunflower leaves, leaves of Gallant soldier
 - Plant Seed: Cotton, Sunflower, Mango, Papaya
 - Brans: Maize, Wheat, Rice
 - Husks: Coffee, Cotton
 - Breweries waste

Suitable feed diets containing easily available components were formulated for the different eco-zones in these three countries. The diet used for Ethiopian plots consists of breweries waste, cotton seed and wheat bran. For the Kenyan feed freshwater shrimps, cotton seed cake and wheat bran are used. In Uganda the main ingredients are “Omena”, cotton seed and maize bran. Silage processes were examined with selected feedstuff, as this method is to be considered as very useful for storing feeds. Growth performance and feed acceptance were tested on *Oreochromis niloticus* with ensiled and not ensiled diets containing leaves of Mexican Sunflower, Sweet Potato and Gallant Soldier, as well as Breweries waste, where the nutrient contents were analysed before.

- The technical optimization and monitoring of the BOMOSA plots is in progress. New Tilapia strains are tested in several areas in Kenya. Experiments to optimize feeding rates and frequencies and stocking densities are performed. Water quality data are regularly collected and temporary water bodies were detected and stocked. Studies on post-harvest preservation methods were done, but could not be evaluated on the first harvests, as all fish were immediately sold.
- Social acceptance and ethical issues were evaluated and the results reported for Kenya and Uganda. First findings on the market-survey can be reported and tools for the cost-benefit analysis were developed.
- The analysis of market conditions for BOMOSA fish products was done for Kenya and Uganda, results for Ethiopia are expected for period 3. Topics like fish types and sources, market functions, pricing of fish, stakeholders involved in fish trade, infrastructure and channels of distribution were evaluated. The survey revealed that fish demand exceeds the supply in all visited market centres, even in smaller ones. The reasons therefore are divers.

Results gained at the end of Period 3:

- BOMOSA was disseminated during several events (e.g. meetings, workshops, technology exhibitions, agricultural shows etc.) and via media coverage (e.g. daily newspapers, magazines, radio, TV etc.). The BOMOSA webpage as a multiplier tool was regularly updated with news; consortium meetings and the final conference were announced. The final conference in Machakos (Kenya) was attended by around 70 participants, like scientists, professionals, decision-makers and community representatives. In the last period sixteen PhD and MSc students were working on their theses, seven MSc theses were successfully finished. Three scientific articles were published in peer-reviewed journals, two articles were accepted by scientific journals and seventeen scientific articles are under preparation. On the community level manuals were produced and further capacity building events were held.
- New locally available raw materials and formulated diets were analysed on their nutritive values. Results show, that especially breweries waste is very high acceptable concerning the nutritive components and even the feeding acceptance. A total of 78 feedstuffs using locally available raw materials have been analysed; 48 in Kenya, 21 in Uganda and 16 in Ethiopia.

Growth performance experiments were conducted in different regions in all three countries by using the new formulations.

- The stress response of three different origins of Nile Tilapia fingerlings was evaluated under application of blue background light. Within this trial it was shown, that especially species with origin "Victoria" were most stress resistant. Different stocking densities and their influence on growth performance and production have been evaluated. For Ethiopia an optimum stocking density of 100 fish / cage could be recommended due to the results. New diets were again developed and tested with changing feeding rates and times. The water bodies were continuously monitored in terms of short term, seasonal and long term limnological changes. Water chemistry of the observed areas is mainly influenced by thermal structure, which is on the other hand mostly influenced by basin morphology and exposure.
- Veterinary analysis was furthermore carried out to determine reasons for eye diseases, which may lead to production losses due to changes in the feeding behaviour. Especially the eyes seem to be easily colonised by bacteria in a first step. Therefore it is recommended that every type of handling has to be performed in a very smooth way and that stocking densities have to be kept optimal. The results of all veterinary surveys were processed for the environmental impact monitoring programme to highlight possible risk factors deriving from BOMOSA cage culture system. A literature survey was conducted to evaluate which post-harvest methods were typical for which country, but due to the fact that all fish of BOMOSA sites were immediately sold after harvesting no direct studies were possible. Therefore in the main hub of Kenya, Sagana Aquaculture Center, smoking kilns were tested with success on locally farmed fish.

Project logo:



Project homepage:

www.bomosa.org



Floating BOMOSA piers



Self floating cage



The Austrian presidents' visit at Sebeta, Ethiopia



Harvesting at Bomet, Kenya



Nile Tilapia in a BOMOSA cage



Sign post at Yemlo, Ethiopia



BOMOSA cages at the Mwea rice channel, Kenya



Fish observatory room at Sagana, Kenya



Exhibition of BOMOSA equipment at final conference



Smoking kiln for BOMOSA fish

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Section 1 - Project objectives and major achievements during the reporting period

General project objectives

BOMOSA is the name given to the “hub and plot” cage-based fish farming system that was prototyped in 2003 - 2004 especially for East African conditions. The net-like BOMOSA cages can be folded, easily transported and handled by two persons without mechanical aid. The proposed INCO project will technically optimize this prototype system and the whole BOMOSA fish farming scheme to prove its economic viability and social acceptability, as well as determine requirements for an institutional environment to support broad uptake of the BOMOSA scheme in Eastern Africa.

The BOMOSA scheme is intended as a network of small-scale, locally-run operations, whereby rural communities will set up and run the plots both during and after completion of the proposed research project. For that reason, the project S&T objectives are also related to fulfilment of locally and regionally defined socio-economic targets such as demands and preferences, integration with existing farming and other economic activities, ethics and roles of women rather than being purely on achieving fish productivity targets.

Kenya, Uganda and Ethiopia share common problems in sustainable management of sensitive and dynamic ecosystems, as well as facing deficits in high protein food supply and an ongoing battle to alleviate rural poverty. The BOMOSA scheme uses an existing fish farm (“hub”) to supply fingerlings (mainly Nile Tilapia at approx. 25g) for rearing within suitable water bodies such as reservoirs, ponds and naturally occurring temporary water bodies formed during the rainy season. Farmers will be trained to rear the fish in cages in their “plots”, harvest them for fresh consumption, to sell locally or to process for long-keeping i.e. drying, smoking and packaging. The fish will be a high protein dietary supplement and/or an additional source of income for subsistence farmers.

Three prototype plots were set up within a single Kenyan eco-zone during 2003 – 2004, which demonstrated technical feasibility. The proposed INCO project offers extensive research with the following scientific and technical objectives:

- Apply a participatory approach to define targets in terms of economic viability and social acceptability at community levels for the new BOMOSA plots.
- Develop and validate an evaluation method using remote sensing to assess and characterize water bodies for use as potential BOMOSA plots.
- Set up fourteen BOMOSA plots and optimize the technology in three types of small (less than 5 ha.) water bodies within four eco-zones across Kenya, Ethiopia and Uganda.
- Evaluate locally available, agricultural by-products and cost-effective processing technologies as a resource for sustainable production of low-protein fish feed.
- Determine requirements and make recommendations for a legal and regulatory framework based on potential veterinary, public health and environmental impacts of BOMOSA.
- Develop capacity building and dissemination material for the local community, relevant authorities and policy makers and the international scientific community.
- Develop a socio-economic model for sustainable introduction and widespread uptake of the BOMOSA scheme in Eastern Africa.

Objectives for the three periods

- Implementing the communication plan and actions necessary for the participatory approach, which will include: setting up a website, establishing committees for each of the BOMOSA plots and launching the first dissemination events to stimulate interest and participation in the BOMOSA project at local and national levels within the African partner countries.
- Benefiting from the learning curve gained through setting up the prototype BOMOSA plots previous to the INCO project, leading to determining baseline environmental and socio-economic data to serve as selection criteria for selecting (communities) for the new BOMOSA plots, which will be engineered, set up and ready for operation by the end of year 1.
- Determining the socio-economic targets relevant to the selected BOMOSA plot communities, which are to be achieved within the project duration.

- Begin developing the remote sensing (RS) evaluation method and produce a first report of potential veterinarian and public health aspects potentially associated with the BOMOSA aquatic farming system.
- Determine sources and quantities of feed ingredients from agricultural by-products within the eco-zones, where the BOMOSA plots are located to ensure that suitable and sufficient feed will be available.
- Organizing regular capacity building and dissemination events at and around fourteen BOMOSA plot communities to both integrate local stakeholders in decision-making and to assess social acceptability, ethical issues and market conditions such as demand, preferences, price sensitivity etc.
- Performing detail analyses on suitability and processing methods of the various potential feed types within the different eco-zones.
- Running and technically optimizing operational procedures of the fourteen BOMOSA plots.
- Perform monitoring of environmental, veterinary and public health parameters at the fourteen BOMOSA plots (Environmental monitoring program).
- Assess post harvest processing methods such as drying, smoking etc.
- Continue implementation of participatory approach to assess (and confirm) social acceptance and to identify any potential conflicting ethical issues.
- Ongoing capacity building and dissemination events.
- Finalizing the research results for use in dissemination material such as policy recommendations, the BOMOSA operational manual, as well as reports on productivity yields achieved using agricultural by-products, veterinarian and public health issues, market conditions, social acceptance and economical viability.
- The most important activity and deliverable of the third year will be producing the Technology Implementation Plan (TIP). This document will summarize the most important project findings and present a plan for scaling up the BOMOSA scheme on widespread scale within Eastern Africa. This does not necessarily relate to increasing the size of the BOMOSA plots to achieve higher productivity through increased economies of scale rather to increase the number of small scale plots across the three African partner countries and to step up dissemination into neighbouring countries. Here arguments will be delivered based on the project findings, especially relating to economic viability, social acceptance, requirements for a relevant institutional environment, contribution to regional development and poverty alleviation in rural communities and the financial input requirements aided through a micro-financing scheme. Potential problems and conflicts of interest will also be included.
- As a dissemination highpoint of the project, the international conference will be organized to take place in Nairobi. Participants and guest speakers will be invited from the African partner countries and neighbouring states, as well as worldwide opinion leaders and stakeholders from academic, non-governmental and political institutions. The TIP and other important project results will be presented, as well as BOMOSA plot visits organized.
- As the conference will mainly be at academic level, dissemination events will also be coincidentally held at BOMOSA plots to build a linking mechanism between the conference and the rural communities and local stakeholders. A selection of local community leaders will be asked to speak at the conference to ensure that participants from the last three years work have the chance to voice their opinions.

Contractors involved

All of the 10 above mentioned partners were involved in the work performance during the three years, whereas every partner contributed in different scale to the respective work packages. Detailed information is given in this report under Section 2 as well as in the Management Report.

Section 2 - Workpackage progress of the period

3.1 WP 1 Consortium Management

To be edited by WP leader according to the requested structure

Responsible: **BOKU**

Work package duration:

Workpackage start	2006-10-01
Workpackage end	2009-09-30

The consortium management is described in Section 3.

3.1.1 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 1.01	Periodical activity and management reports (including financial issues) according to the contract	WP 1	recurring	recurring
D 1.02	Audit Certificates	WP 1	recurring	recurring
D 1.03	Final reports according to contract with key results and policy recommendations	WP 1	2008-09-30	2010-04-01
D 1.04	Documentation of workshops and meeting	WP 1	recurring	recurring

3.1.2 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 1.1	Activity and management reports (including financial issues) submitted	WP 1	recurring	recurring	BOKU
MS 1.2	Final periodic report submitted	WP 1	2009-09-30	2009-09-30	BOKU

3.2 WP 2 Participatory approaches, capacity building and dissemination

To be edited by WP leader according to the requested structure

Responsible: **OEAW**

Work package duration:

Workpackage start	2006-10-01
Workpackage end	2009-09-30

3.2.1 Workpackage progress overview

A communication plan was established to ensure adequate and consistent communication principles tailored towards the various stakeholder groups. Plot committees were established at all BOMOSA sites and served as institutionalized dialogue platform, integrating local communities, scientists and governmental officials. The BOMOSA approach/technology was disseminated within community meetings, scientific conferences/workshops, technology exhibitions, agricultural shows, on-site demonstrations with high level decisions makers & multipliers, daily newspapers, magazines, radio & TV broadcasts and via the BOMOSA webpage. Dissemination and capacity building material was produced, such as technical papers, manuals & posters, scientific articles & posters, DVD's, BOMOSA flyer & calendar and articles in newspapers and magazines. Overall, the dissemination materials reached more than 7.5 million people. Capacity-building measures on fish farming techniques, fish cage management, fish diseases/parasites, remote sensing and fish processing/marketing were implemented for consortium members, plot committees, local communities and key-people/multiplier (students, young scientists and professionals). BOMOSA technology could be embedded in the academic curriculum of an international M.Sc. programme. The final BOMOSA conference was attended by more than 70 participants drawn from 8 countries. The "book of abstracts" (91 pages) was published, containing the proceedings of 3 years of BOMOSA research activities. Seventeen M.Sc. and five Ph.D. students were carrying-out their theses within the BOMOSA project. Scientific presentations and posters were presented at 57 conferences, workshops and seminars. Technical posters and presentations were presented at eleven national/international exhibitions and agricultural shows in Eastern Africa. Eight scientific publications were published, five articles were accepted/submitted and fifteen scientific articles are under preparation.

3.2.2 Objectives and starting point of work at beginning of reporting period

In order to make a substantial contribution to poverty alleviation in Kenya, Ethiopia and Uganda, the project incorporates participatory processes right from the beginning and throughout the project duration. The objective of this work package is to integrate communication based activities to achieve holistic involvement of a wide variety of stakeholders, necessary to ensure take-up at local community levels and thus effectively shortening impact times. The overall intention is local operations to bring benefits to rural communities.

The first steps are to characterize existing local community structures and to establish so-called "Plot Committees" for each of the BOMOSA plots, which will include 6 representatives from the key stakeholder groups forming a decision-making body at the local level. The Plot Committee will ensure that local, rural population is adequately represented in decision making processes at both planning and implementing level. Participatory involvement of local communities will determine local planning and implementation measures to achieve locally defined goals - high protein dietary supplement and/or fish as a source of additional income. In this way fish will become both an affordable food for the rural population and a source of additional income, as a result of their own efforts and ingenuity.

The work package comprises a logical combination of establishment and management of the participatory approach with capacity building and dissemination tasks, which all lead to the common goal of broad take up of the BOMOSA scheme. Participatory mechanisms will ensure to link scientific

research with real “on the ground” needs for development of sustainable aquaculture solutions. The WP will be lead by Participant No. 2 due to its 30 years of experience in supporting capacity enhancement processes and networking in the East African region. This well-established intercultural network of trust is safeguarding the successful mix of specific qualities of European and East African partners at various levels.

3.2.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 2.1 Communication planning (M0 – M3)

A communication plan was established to ensure adequate and consistent communication principles tailored towards the various stakeholder groups, multiplier/key-institutions and general public. Participatory approaches were utilized in all decision making processes in order to strengthen local ownership and to achieve sustainable solutions. The communication plan included communication principles to make sure that the whole project consortium is using same “approach & language” (e.g. key-principles: BOMOSA is not a donor; BOMOSA provides information, expertise, technical know-how, infrastructure, fish fingerlings, fish feed processing technology and back-stopping services – BUT communities who want to join BOMOSA must show self-initiative and discuss/decide their priorities and contributions by themselves). The BOMOSA website (www.BOMOSA.org) was designed and structured within a participatory process, consulting consortium partners and various stakeholder groups. The webpage served as pivotal instrument to enhance the dissemination of BOMOSA. The BOMOSA website was updated and downloadable documents and dissemination material were added recurrently (documents such as: project reports, technical manuals, posters, publications, theses; dissemination material such as: BOMOSA song, flyer, articles and calendar).

Achievements for task 2.2 Establish plot committees (M3 – M6)

Plot committees were established at all BOMOSA sites and served as institutionalized dialogue platform, integrating local communities, scientists and governmental officials. The typical plot committee consisted of a plot manager, plot scientist, community representative, community merchandiser, community teacher and women’s representative, however, for some BOMOSA plots other configurations were set-up upon discussions with local communities. The plot committees were set-up before the construction of BOMOSA plots, safeguarding the participation of local communities from the very beginning. Structured discussion processes between the project management team and local communities ensured that all components of local societies (e.g. gender, tribes, clans, age-groups) were represented in the participatory decision making processes. The plot committees were fully responsible for the plot management/development and ensured ownership of the local communities throughout the project period.

Achievements for task 2.3 Capacity building / dissemination material (M3 – M36)

BOMOSA project sign-posts were set-up at all BOMOSA plots and at main roads junctions nearby BOMOSA sites. Several BOMOSA posters depicting/explaining BOMOSA technology/management were produced as on-site capacity building and dissemination material. A BOMOSA information flyer was printed in four languages. Produced were BOMOSA give-aways such as t-shirts, caps, ball-pens, calendars and special “BOMOSA corners” were established at the BOMOSA hubs Sagana Fish Farm and Sebeta Fish Research Center (disseminating posters, flyers, BOMOSA song and selling BOMOSA give-aways). A BOMOSA song was produced and played in Kenyan radio stations, at BOMOSA dissemination events and for mobilizing communities. BOMOSA articles were published in various popular daily newspapers, magazines, special-interest journals and internet newsletter/magazines. BOMOSA broadcasts were transmitted in radio (Kenya, Ethiopia, Czech Republic) and TV (Ethiopian and Czech state television). A 60 minutes documentary film (“Teach Them How to Fish”) was produced by the Czech state television and was made available on DVD. Overall, the dissemination materials reached more than 7.5 million people. Standardized field and lab-protocols for pathological, parasitological and bacteriological examination of fish, identification of fish diseases, measuring physico-chemical parameters, determining phytoplankton/bacteria composition/abundance/biomass, processing of potential toxin producing cyanobacteria were

produced. A manual and DVD on “GPS & GIS applications and processing of satellite images” was produced and delivered to all BOMOSA consortium members. Seventeen M.Sc. and five Ph.D. students were carrying-out their theses within the BOMOSA project. Twelve M.Sc. theses and one Ph.D. thesis were finished successfully during the 3-year term of the project. Eight scientific publications were published, two articles were accepted by scientific journals, 3 scientific articles were submitted, and fifteen scientific articles are under preparation.

Achievements for task 2.4 Capacity building / dissemination events (M3 – M36)

The BOMOSA approach/technology was disseminated within at least four community meetings at each BOMOSA plot. More than twenty capacity building events were held for BOMOSA plot communities on the management of BOMOSA plots, principles in fish farming, fish feeds, fish processing and fish marketing. Guided on-site excursions/demonstrations were organized for representatives of African fisheries authorities, international organizations, local politicians, community leaders, schools and development agencies. Kenyan, Ugandan and Ethiopian ministers, members of parliament and the Austrian president visited BOMOSA sites. BOMOSA technology was presented at five agricultural shows and technology exhibitions in Eastern Africa. BOMOSA consortium members organized three international exhibitions/conferences wherein BOMOSA technology was presented to scientists, policy-makers, NGO's and the private sector in Eastern Africa. Three capacity building workshops were held on the application of remote sensing methods for identifying water bodies from satellite images, GIS applications and GPS mapping. Six workshops and seminars were organized on fish pathology, fish parasitology and diagnosis of fish diseases. Excursions to BOMOSA sites were organized for 60 young scientists from Kenya, Uganda, Ethiopia, Sudan, DR-Congo, Tanzania and Zambia, within the “International Post-Graduate Training Course on “Tropical Limnology”. From October 2009 onwards BOMOSA technology will be embedded in the academic curriculum of an international M.Sc. programme taught at Egerton University, Sagana Fish Farm and KMFRI. Thus, BOMOSA technology was successfully integrated into university programmes in Eastern Africa. Scientific presentations and posters were presented at 57 conferences, workshops and seminars. Technical posters and presentations were presented at eleven national/international exhibitions and agricultural shows in Eastern Africa.

Achievements for task 2.5 Project Conference (M25 – M35)

The international BOMOSA project conference was organized from 2nd to 4th September in Machakos, Kenya. A conference announcement flyer was produced and disseminated via the BOMOSA webpage. Additionally, 1000 hard copies were sent to institutions of relevance. The conference was attended by more than 70 participants drawn from 8 countries. The conference participants included scientists, technologists, aquaculture professionals, representatives of international organizations (FAO), community leaders and key-stakeholder groups. The conference programme included 38 powerpoint presentations, video presentations, technology exhibitions, plus excursions to BOMOSA plots and the BOMOSA hub Sagana Fish Farm. The conference announcement flyer and detailed “book of abstracts” were widely disseminated and are downloadable from the BOMOSA webpage. The “book of abstracts” (91 pages) was published, containing the proceedings of 3 years of BOMOSA research activities: Drexler S.-S., Waidbacher H. (Eds.) Book of Abstracts (Final Conference; Machakos, Kenya; 2nd to 4th September 2009), Universität f. Bodenkultur Universitätsbibliothek, ISBN-Number: 978-3-900962-84-5. The conference was covered by mass-media and two articles were published in daily newspapers.

3.2.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 2.1 Communication planning (M0 – M3)

None

Deviations from task 2.2 Establish plot committees (M3 – M6)

All changes related to the composition of plot committees and eventual shifts of BOMOSA plots were discussed with local communities and sustainable solutions could be achieved.

Deviations from task 2.3 Capacity building / dissemination material (M3 – M36)

None

Deviations from task 2.4 Capacity building / dissemination events (M3 – M36)

None

Deviations from task 2.5 Project Conference (M25 – M35)

The final project conference was attended by 72 participants, instead of 100 participants stated in the project proposal. The downsizing of the BOMOSA conference was done to maximise personal interactions and discussions during the conference and to implement field-trips and field-sessions cost effectively.

3.2.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 2.01	Communication Plan and BOMOSA website	WP 2	2006-12-31	2007-02-17
D 2.02	Capacity building and dissemination material and documentation	WP 2	recurring	recurring
D 2.03	Conference proceedings	WP 2	2009-08-31	2010-04-01

3.2.6 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 2.1	Communication plan completed and website launched	WP 2	2006-12-30	2007-02	OEAW
MS 2.2	Committees are established for all plots	WP 2	2007-03-31	2007-04	OEAW
MS 2.3	Capacity building / dissemination workshops are well attended	WP 2	recurring	recurring	OEAW
MS 2.4	Project conference is attended by at least 100 participants	WP 2	2009-09-30	2009-09-30	OEAW

3.3 WP 3 Select sites and establish trial BOMOSA plots in target countries

To be edited by WP leader according to the requested structure

Responsible: **MU**

Workpackage duration

Workpackage start	2006-10-01
Workpackage end	2007-09-30

3.3.1 Workpackage progress overview

The objective of this work package was to determine the criteria for selection of BOMOSA plots and future sites, develop feeder technology and develop fingerling transportation protocols. The selection criteria involved several aspects, which touched on environment, infrastructure, and socio-economics. All the aspects progressed as planned except for the light technology which is yet to be implemented.

3.3.2 Objectives and starting point of work at beginning of reporting period

The objective of this work package is to determine characterization criteria for the BOMOSA plot locations based on pre-project experience in conjunction with Tasks 4.1 (Environmental data) and 7.1 (Baseline economics and social acceptance) and to select a total of fourteen BOMOSA plots (ten in Kenya, two in Ethiopia and two in Uganda) set up for the purpose of research, validation and dissemination within the proposed INCO project. The BOMOSA plots essentially comprise cages and piers / walkways, which are partially fixed and / or floating depending on the characteristics of the individual sites. The plots themselves are relatively inexpensive to set up so a range of plots will be set to identify and analyze factors of social acceptance and economic viability within three plot types across four eco-zones. Refinement of the current design and construction techniques according to plot type is planned within the project. Furthermore, semi-automated (clockwork-driven) feed dispensers and solar-powered floating water lights for attracting insects, as well as knowledge in setting up and operating the plot play significant roles.

The new BOMOSA plots will be located in the following four eco-zones:

- Humid
- River and lake floodplains
- Highlands (above 2000 m sea level)
- Semi-arid (man-made and temporary rain-fed water bodies)

The provisional plot to eco-zones planning is as follows:

- Kenya – 10 plots: covering all targeted eco-zones
- Ethiopia – 2 plots: semi-arid zone (e.g. Southern Rift Valley) and arid highlands
- Uganda – 2 plots: Humid zone and lake floodplain (e.g. Lake Chioga)

The three plot site types are described within WP 5.

The plot site selection criteria such as physical parameters, water quality / chemical criteria, variation on limnological and seasonal condition, social acceptance and willingness through well-organised, proactive local councils will all be considered. These criteria will be listed and described within a checklist based upon the experience already gained over the last two years in Kenya and will be one on the main agenda points at the Kick-off meeting.

3.3.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 3.1 Determine characterization criteria and selection of the BOMOSA plots (M0 – M6)

The initial BOMOSA plot characterisation and selection criteria was discussed and finalised at the Kick-off meeting at Machakos on 3rd to 11th November 2006. Site characterisation and selection criteria were further refined in a meeting held at the “Hippo Buck Hotel” in Homabay (Kenya) between the Kenyan and Ugandan partners on 14th to 17th November 2006.

The meeting recommended a checklist for characterisation of BOMOSA plot sites based on the basic parameters as follows:

1. Water quality, air temperature, water temperature, hardness, turbidity, dissolved oxygen, pH, alkalinity, conductivity, phosphorus concentration, nitrogen concentration, productivity (Chlorophyll a) etc.
2. Infrastructure, communications and roads
3. Security
4. Land tenure rights
5. Socio-economic, ethical and livelihood systems, livelihood base, culture and social structure, main diets/optional diets
6. Income levels/poverty levels, demographic characteristics e.g. age distribution, beliefs or religious associations with water bodies

After evaluation of the dams, those which met the environmental selection criteria were vetted on other aspects including social-economic requirements. Site committees were established at all plots. However, social and economic aspects proved quite complex and this entailed several trips and meetings with stakeholders to iron out thorny issues and establish working committees. In all sites various interest groups were represented, such as women, youth and other users of the water to satisfy all stakeholders for a better working atmosphere within these communities. The following dams were used to develop future site selection criteria:

Table 1: Summary of selected BOMOSA sites

Country	Region	Eco-zone	Site	Character
Kenya	Machakos	Arid / Semi-arid zone	Ngeki	Community reservoir
			Ngei	Private reservoir
			Lukenya	School reservoir
	Mt. Kenya	Highland	Ruthagati	Private but being run by community
			Mairo	Community
			Sagana	Government
	Lake basin	River and lake floodplains	Harambee	Community
			Mamboleo	Private
			Kapkesosio	Community
Ethiopia	North Shoa	Semi-arid	Yemlo	Community
			Alage	Government
	Eastern Shoa	Semi-Arid		
Uganda	Kamuli District	River and lake floodplain	Ndolwa	Community
			Kasolwe	Community

Water quality is one of the key determinants of fish growth. The degree of influence is being dependent on the prevailing values of these parameters in a water body and also on the rate of change of the parameters. The most important key water quality parameters for cage culture are (see Figure 1): temperature, dissolved oxygen (DO), pH, ammonia, alkalinity and hardness.

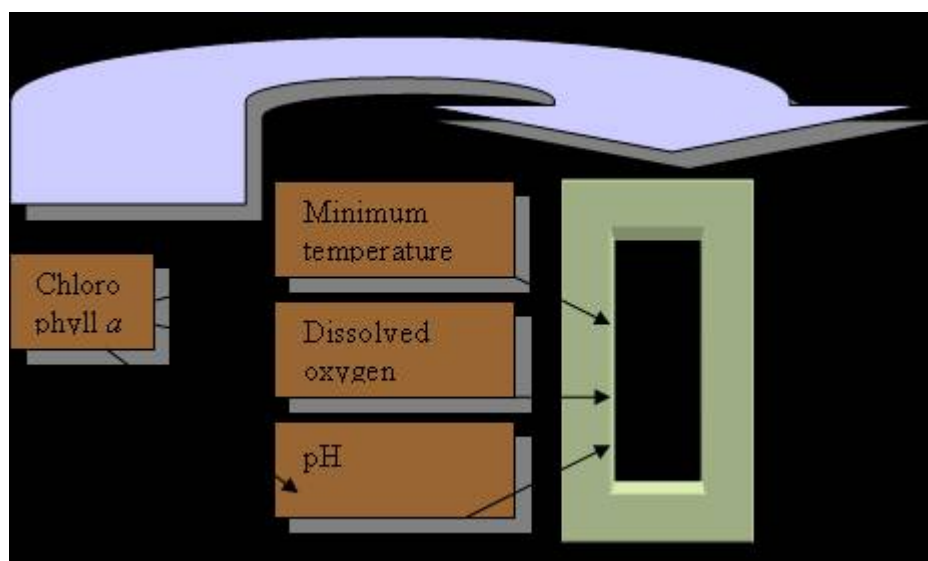


Figure 1: Influencing parameters in water bodies

These parameters were monitored on a long term basis. At the same time, fish growth trials were conducted to determine which of the water quality parameters influence fish growth significantly. At the end of the trials, the relationships between fish yields and water quality parameters were evaluated using multiple linear regression. The results of the analysis revealed that minimum temperature was the most important parameter *per se*. Average temperature was not an important parameter for site evaluation. Dissolved oxygen and pH were only important when chlorophyll *a* or ammonia were factored in to the relationship. However, when chlorophyll *a* or ammonia were not included, both DO and pH became insignificant in the determination of fish yields. Without chlorophyll *a* and ammonia, DO had a weak positive relationship with fish yields while that of pH was also weak but negative. The direction of effect of the relationships were reversed in the presence of chlorophyll *a* but remained the same direction when un-ionized ammonia was factored in to the prediction equation. However, both DO and pH became significant determinants of fish yields. Inclusion of chlorophyll *a* with minimum temperature, DO and pH accounted for 98% of the fish yield variation while that of ammonia accounted for 90%, indicating that chlorophyll *a* was more important than ammonia in determining fish yields. The diagram, which was constructed through path analysis is presented in Figure 1. There are several important observations to note. An increase in DO at constant temperature, pH and chlorophyll *a* decreased fish yields while the opposite is expected. The decrease in fish yield as DO increases can be accounted by the following facts; the main source of DO in the dams is photosynthesis, therefore DO increases when photosynthesis is intense. At the same time, the dams became increasingly stratified and as a result, the lower water column became unsuitable for occupation by the fish (see Figs 2 & 3).

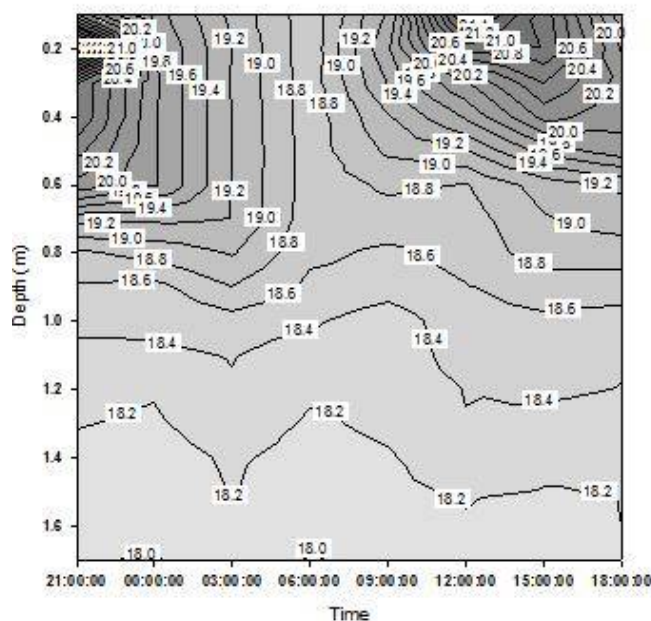


Figure 2: Mailo depth-time temperature isopleths

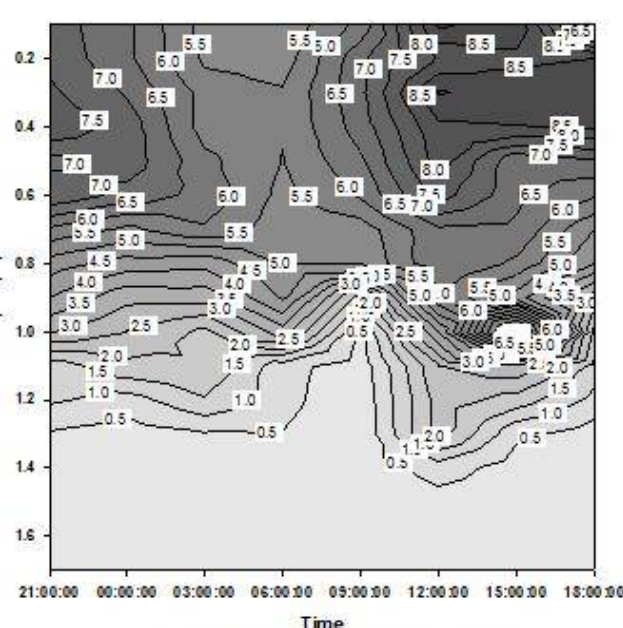


Figure 3: Mailo depth-time DO isopleths

Such conditions would lead to concentration of fish at the surface. When similar conditions occur in ponds or other systems, fish move to seek safe haven in other areas of the pond but in cages, fish are confined and the only safe haven is the surface, where fish concentrate and increase the relative density. Crowding of fish could lead stress and therefore increase the susceptibility for attack by diseases and other pathogenic organisms. On the other hand, increase in pH at constant temperature, DO and chlorophyll *a* increased fish yields. Like DO, pH increases during photosynthesis, a process in which total ammonia ($\text{NH}_4^+ + \text{NH}_3$) is utilized as nutrient. As photosynthesis progresses, and the pH increases, total ammonia levels reach negligible levels. One of the roles of pH in the toxicity of ammonia is to increase the un-ionized ammonia (NH_3) component of the total ammonia, which is toxic to fish. However, despite the high levels of pH, it is possible that the toxic component will decline with increase in pH since its source of supply, total ammonia is also declining.

When the other parameters (DO, pH and temperature) were held constant at their means, an increase in chlorophyll *a* decreased fish yields. This may have been a direct effect occasioned by respiratory problems from increased turbidity or indirectly through increased oxygen demand, thus leading to low oxygen levels in the hypolimnion.

The results were equally interesting when un-ionized ammonia was factored in to the prediction equation. Increasing un-ionized ammonia at constant temperature, DO and pH but in absence of chlorophyll *a* led to an increase in fish yield. This again is surprising given the fact that un-ionized ammonia affects fish yields negatively. At constant pH, un-ionized ammonia would increase as the supply of total ammonia increases. This would occur only during periods of mixing where hypolimnetic water, rich in ammonia intrudes the epilimnion. The hypolimnetic water is also rich in carbon dioxide and the latter is known to suppress the toxicity of ammonia. In addition, when DO, minimum temperature and un-ionized ammonia were held constant, fish yields declined as pH increased in absence of chlorophyll *a*. As pH increases, free carbon dioxide decreases in the water and the toxicity of un-ionized ammonia increases leading to a decline in fish yields. All these observations reflect the thermal structure of the water bodies, which in turn implicate the prevailing air temperature regimes, basin morphology, exposure and relative depth. From these findings it is possible to formulate site selection criteria using only a few physical parameters and some visual characteristics. The following may form a suitable guide. Dams which appear green, with secchi depth readings < 20 cm, and are well sheltered from wind action (see Figure 6 and Figure 7) are not suitable for cage fish farming. However, ponds with secchi depth < 20cm but well exposed to wind action (see Figure 7) may be highly productive because of mixing, good supply of oxygen and increased volume of occupation (see Figure 4 and Figure 5). Production is highly enhanced in these dams if the minimum temperature is above 24°C. Dams which have relatively small surface area < 800m² and have depths > 3m may not be suitable for cage culture if they are not well exposed to wind action.

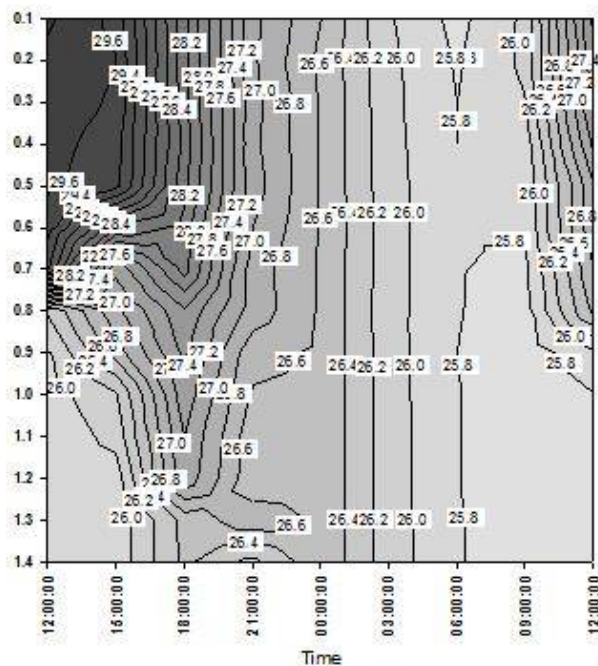


Figure 4: Harambee depth-time temperature isopleths

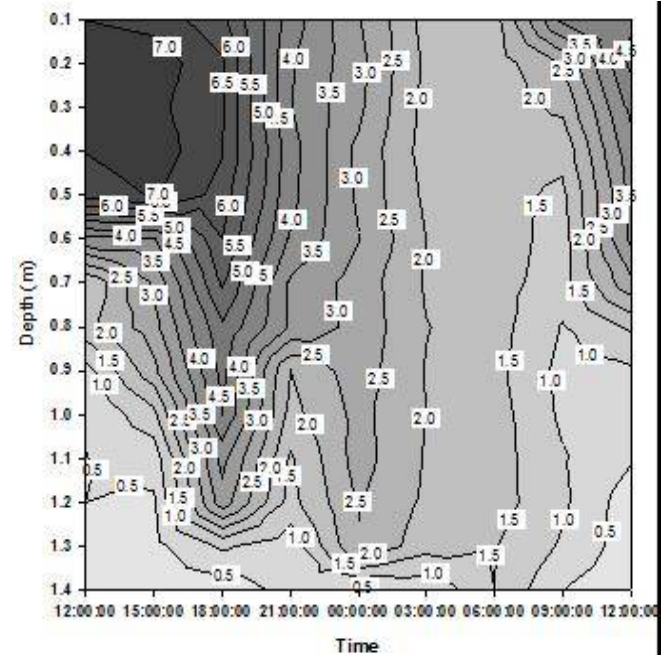


Figure 5: Harambee depth-time DO isopleths



Figure 6: Well protected



Figure 7: Well exposed

Achievements for task 3.2 Engineering of the BOMOSA cage and piers/walkways (M7 – M12)

Engineering (final design and construction) of piers for the selected BOMOSA plots was designed, discussed and adopted by Kenyan partners at a BOMOSA workshop meeting held in Machakos from 27th to 28th March of 2007 (see Figure 8). The initial plan was to have a fixed pier on the reservoirs. However, due to fluctuating water levels a floating pier was developed to accommodate reservoir level changes. The initial plan was to have a fixed pier on the reservoirs. However, due to fluctuating water levels a floating pier was developed to accommodate reservoir level changes.

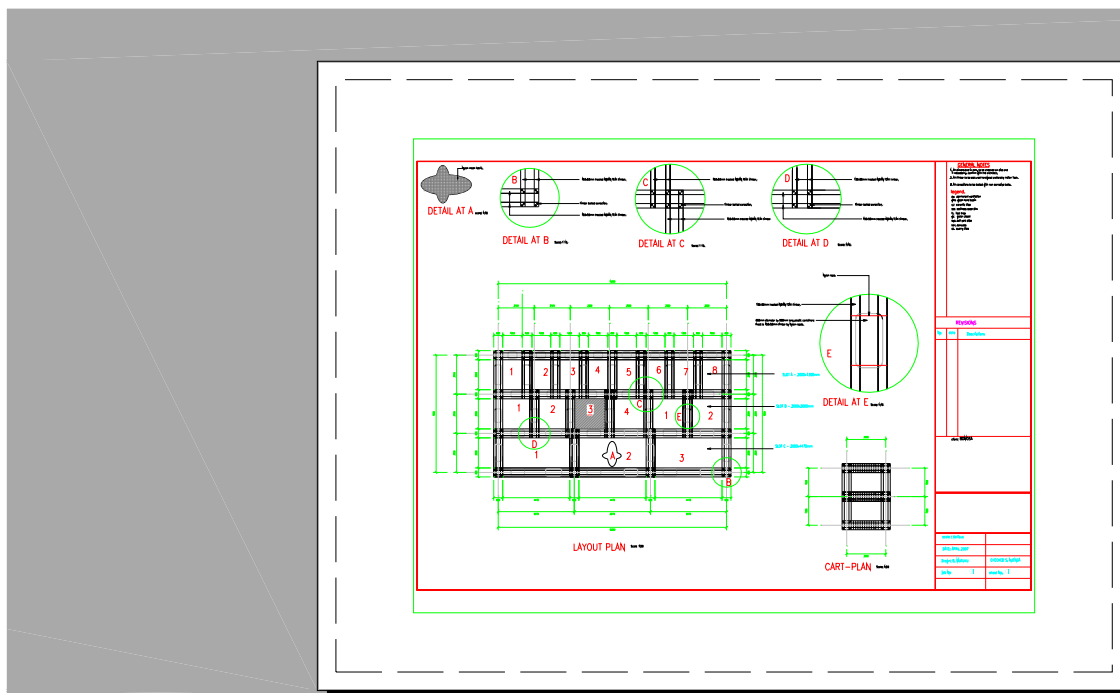


Figure 8: Architectural layout of a floating pier

Ten BOMOSA piers were constructed in the three designated regions of Kenya. Each pier accommodated ten cages and had two larger cage provisions for holding fingerlings and fish harvests. The design was adopted in Ethiopia and Uganda and there the piers were constructed on the selected reservoirs. The system includes a shuttle to convey fingerlings and feeds from the shore. The shuttle is the basic unit of the pier. The first systems were quite bulky but those which have been adopted by farmers are much light with fewer timber than the former. The piers versatile and can be moved from one place to another in case its location becomes shallow.



Figure 9: Floating pier with a shuttle



Figure 10: Fixed pier

Cages:

One hundred cages were constructed (see Figure 11) in Kenya and 40 in Ethiopia and Uganda, 20 for each country. Each cage consisted of a pair of 2 inch diameter PVC rings and wrapped with a netting material. The BOMOSA cage has a self regulatory floating system. The top ring serves as a floater and measures 1.60m² while the lower ring, which is perforated and measures 1.20m² serves as the sinker. These rings keep the cage fully stretched thus preventing the collapse of the cage structure and reduction in effective volume.



Figure 11: BOMOSA cages

Many challenges had to be overcome in construction of the cages, which included drawn out bureaucratic import and clearing procedures for the nets, which led to some delays. However, the cages have been constructed and were ready in time for installation at the reservoirs. Students and school pupils were also involved in the construction of piers and cages as a form of dissemination.

Culture species:

The culture species identified from the local fish stock was Nile Tilapia (*Oreochromis niloticus*). Fingerling production in Kenya was done at Sagana and Sangoro Fish Farms. In Uganda fingerling production is based at Kajansi Fish Farm; while in Ethiopia the fingerlings were sourced from the wild (Lake Babagayu and Hora for Alage and from Mulu Reservoir for Yemlo). In Kenya, three strains of *O. niloticus* from lakes Victoria and Turkana, and Sagana aquaculture centre were evaluated. The growth performance of the Victoria strain was found to be better than the other two which performed equally. Also catfish was stocked at large in three temporary water bodies in Machakos district-Kenya. However, no harvests were made because the communities consumed everything before the day of harvest.

Plot scientists:

Individual project team members were nominated and approved as the responsible “Plot Scientists” for each of the BOMOSA plots.





Figure 12: Pier construction at Ugandan and Ethiopian BOMOSA plots

Achievements for task 3.3 Lights and feeder technologies (M7 – M12)

In Kenya 100 feeders were assembled using locally available materials (timber and PVC canvas). The only item which was imported was the clockworks. The local assembly reduced the cost of the feeders dramatically. The feeders have been tested at all the reservoirs and found to be working effectively with minimum maintenance, which involves only oiling. Uganda and Ethiopia acquired fully assembled feeders.



Figure 13: Clockwork feeder components and assembly

Achievements for task 3.4 Rearing and transport of fingerlings (M7 – M12)

As mentioned above, fingerlings in Kenya and Uganda were produced in hatcheries in the hubs at Sagana and Sangoro in Kenya, and at Kajansi in Uganda, while in Ethiopia wild collected fingerlings were used.

An example of one of our delivery protocol is outlined below:

- The tilapia post fingerlings were transported from the pond to the hatchery and stayed in the hatchery for 28 hours.
- Packaging started at 3.30 am in the morning and was completed at 4.00 am (to avoid daytime heat).
- Sixteen (16) packages were used with 100 post fingerlings each.
- Fish were scooped from the holding tank and then put on holding basin for counting to the package and then oxygenated and tied with rubber.
- During counting water was allowed to flow through holding basin.
- The packaging lasted for about 50 minutes.
- The fingerlings left Sagana at 4.00 am and arrived in Machakos at 6.20 am.
- Acclimatization of the fish started immediately after arrival and lasted 1 hr and 30 min. Fish were stocked in the cages at a rate of 100 pieces per cage.
- Other fish were stocked in 2 large hapas at a rate of 100 pieces each.
- Thirty three fingerlings were dead by the time stocking was over but the rest was in good condition.



Figure 14: Pond seining



Figure 15: Cooler boxes for fingerling transport



Figure 16: Packaging of fingerlings



Generally the fingerling production and transportation process has been done successfully in all countries.

3.3.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 3.1 Determine characterization criteria and selection of the BOMOSA plots (M0 – M6)

The target set in the technical annex was to select sites and to construct 10 BOMOSA plots in Kenya, 2 in Ethiopia and 2 in Uganda. In Kenya only 9 sites were constructed. The consortium decided to leave one site out to wait for a community demand driven site in the second year of the BOMOSA project. This was agreed in a meeting on 6th March 2007 at Sagana Aquaculture Centre site selection consortium meeting. The fact that there were 9 plots instead of 10 had no major impact on the overall project progress or the acceptance in the Kenyan communities. The main aim for the delay of the 10th plot in Kenya was to rely on the performance and reputation of the first 9 plots to generate further interest within the stakeholders, i.e. to let the community approach the consortium and request for a plot. This actually happened and the tenth site was set up at Mwea irrigation cheme along the feeder channel.

Deviations from task 3.2 Engineering of the BOMOSA cage and piers/walkways (M7 – M12)

There was no deviation and the work was completed as planned.

Deviations from task 3.3 Lights and feeder technologies (M7 – M12)

Lights have not yet been installed. A few trials were carried out in Kenya with white, red and blue lights. Fish were observed actively feeding on insects and the attraction depended on the colour of light and blue light was most favourable. However, the full adoption of the solar powered light system is yet to be explored and designed. A lot of effort has been devoted to installation of the basic facilities with an emphasis on locally available and/or fabricated facilities and equipment in a bid to cut down on cost and avoid the hassle of lengthy bureaucratic procedure associated with importation.

Deviations from task 3.4 Rearing and transport of fingerlings (M7 – M12)

There have been no deviations.

3.3.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 3.01	A criteria checklist for BOMOSA plot site selection	WP 3	2006-10-31	2006-11
D 3.02	Plot Design Documents for each BOMOSA plot: Site study, owner and authority approvals and first level designs	WP 3	2007-03-31	2007-04-17
D 3.03	BOMOSA plots set up and fingerlings delivered	WP 3	2007-09-30	2007-09-30

3.3.6 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 3.1	Fourteen BOMOSA sites selected and confirmed for participation	WP 3	2007-04-30	2007-04	MU
MS 3.2	Fourteen BOMOSA sites are set up and ready for fingerling delivery	WP 3	2007-09-30	2007-10	MU

3.4 WP 4 Analyze environmental, veterinary and public health aspects for development of aquaculture legal and regulatory frameworks

To be edited by WP leader according to the requested structure

Responsible: **EIAR**

Work package duration:

Workpackage start	2006-10-01
Workpackage end	2008-09-30

3.4.1 Workpackage progress overview

This final report covers major achievements that have been accomplished in the three years of the project period. Some of the activities have been accomplished as planned. However, there have been some delays that occurred due to technical problems. Work package (WP) 4 consists of four major tasks that deal with different topics such as the analysis of the environment, application of remote sensing techniques, assessment of public health and veterinary aspects of the BOMOSA systems as well as analysis of fisheries legal and regulatory frameworks currently available in Ethiopia, Kenya and Uganda. Because of the diversified nature of the activities several actors were actively involved to accomplish the proposed activities.

This part was compiled in collaboration with the University of Bologna, the ENKI group from the Czech Republic as well as fellow colleagues from Kenya and Uganda. The veterinary and public health aspect was summarized by Italian colleagues from Bologna University. They have also been extremely helpful in the compilation and synthesis of the revised versions of deliverables 4.6 and 4.10 that deal with the legal and regulatory framework of the BOMOSA project.

3.4.2 Objectives and starting point of work at beginning of reporting period

Determine and analyze environmental, public health and veterinary aspects for legal and regulatory frameworks of aquaculture development in Kenya, Ethiopia and Uganda to reduce externalities and avoid irreversible damage through potentially negative human and environmental impacts associated with development of aquaculture in Eastern Africa. The work package objectives include:

- Analyze, and if necessary, collect data and information from BOMOSA plots (established for feasibility in 2003 in Kenya) for design of the environmental monitoring program of the new BOMOSA plots
- Application of Remote Sensing (RS) techniques to evaluate potential water bodies (as a decision making tool) for designing the scale up of BOMOSA within the TIP (WP 7)
- Assessment of public health and veterinary aspects of the BOMOSA cage culture system
- Analysis of current fisheries legal and regulatory frameworks and to apply findings within the work package to make recommendations for establishment of a suitable institutional environment to enable the sustainable scale up of BOMOSA aquaculture in Kenya, Ethiopia and Uganda.

The resulting scientific reports and recommendations from this work package will serve as basis for decision makers and officials on the sustainable development of aquaculture with respect to BOMOSA cage culture. Moreover, baseline data can also be used for scaling up and expansion of the BOMOSA social-economic model at a broader scale in Ethiopia, Kenya and Uganda. The Remote Sensing (RS) analysis will provide up to date, descriptive and reliable information on potential water bodies found in each country. Conducive policies and regulations as an institutional environment are needed for general acceptance and scaling up of BOMOSA fish cage farming in Eastern Africa. To this end, sustainable aquaculture development policy recommendations for policy makers will be formulated.

3.4.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 4.1 Analyze environmental data from the prototype Kenyan BOMOSA plots (M0 – M6)

The reservoirs Ngei, Ngeki and Kavovi are situated in Machakos district and were chosen to analyse environmental data. All three of them were built in the 1970s by damming small rivers for domestic use, irrigation and livestock purposes. Ngei with a size of 0.75 ha has an average depth of 5 m and is fed seasonally by a nearby river. With 2 ha size and a depth of about 2 m the Ngeki pond is used as a multipurpose reservoir (irrigation, life stock, domestic use). Kavovi covers an area of 1 ha (average depth is 4 m) and is fed by a seasonal river. Almost half of its area is covered by a reed belt; additionally other macrophytes like *Nymphaea* could be found. All the three reservoirs showed hypereutrophic conditions, temporal variations were observed for phosphorus compounds and nitrite. The reservoirs are well buffered, so big changes in pH could not be expected. The ponds express a warm polymictic mixing regime due to their shallowness. A significant influence of seasonal changes with high loadings from the catchment area was detected mainly in the rainy season. Phytoplankton comprised mainly Chloro-, Euglenophytes, Diatoms, Dinophyta and Cyanobacteria, the last two typically predominating in the rainy season.

Achievements for task 4.2 Develop and apply a Remote Sensing (RS) based evaluation method to assess potential water bodies (M0 – M24)

Achievements for task 4.2.1 First stage RS analysis (M0 – M12)

Data inventory

The main goal was to establish an inventory of existing LANDSAT data for the selected areas over various times (e.g. 1984 -2003). It was found out the Maryland University (ESDI, Global Land Cover Facility), USA provides the large archive of Landsat data for free, for research and education purposes.

Stage one of WP 4.2 provided the BOMOSA project with 46 orthorectified LANDSAT satellite images found and obtained free of charge. The scenes were downloaded from (<http://glcfapp.umiacs.umd.edu/index.shtml>) and adjusted for other use. Originally it was deliberated to catch the situation in rainy and dry season. Because of dense cloud cover during rainy season it was not reasonable to download and process these data. The scenes are from various times horizons catching two decades in dry season – in eighties and 2000's and are geometrically transformed into UTM-WGS 84 system. The inventory of existing LANDSAT data was extended with digitalized topographic maps in scale 1: 500.000. Based on satellite survey, these maps had been produced by the Military Topographic Directorate in former USSR. In August 2006 the complete coverage for Africa was released for free use. Any of these collar-clipped and, thus, mosaic map sheets can be downloaded via the <http://www.madmappers.com/htm/News.htm> link. These maps have enormous potential for advanced steps of the Task 4.2. The maps can be used for any GIS analyses and/or syntheses even considered within the BOMOSA project.

The list of all downloaded map sheets is provided in the Deliverable 4.2. and on CD (Table and image survey of inventory results).

Ground-truthing data were being collected during both the Remote sensing course part 1 (2-13 March 2007) and successive week. Whilst measurement techniques form part of the course syllabus and particular field data achieved were immediately used for training purposes, main goal was to collect actual ground-truth data for eventual later interpretation of the Landsat data.

In collaboration with all participants of the course (Kenya) and with Ugandan colleagues of the WP 4.2 team there were the particular field measurements taken and ground-truthing data collected by GPS at given localities as follows.

- o Mitubiri, Sagana, Masinga Dam, Tumutumu, Ruthagati in Kenya
- o Kasolwe, Ndolwa, Bukngu, Lake Kyoga in Uganda

The Deliverable 4.2 brought the first insight into the remote sensing and possibilities of its use for water analyses. The main interest was targeted on following topics:

1. Basic characteristics of Landsat data
2. Detectability of ecozones using multispectral Landsat data
 - Combination of a 3-band false colour (in RGB colour system) and soft radiometric enhancement was used to distinguish between humid and semi-arid ecozones. The method was applied on three model areas – surroundings of Addis Abeba (Ethiopia), mosaic of two scenes including the area between Mt. Kenya and Machakos (Kenya) and Lake Kyoga region (Uganda)
3. Detectability of water heterogeneity
 - RGB three-band false colour composites and histogram stretching were the main procedures used to detect surface heterogeneity of water. Three model areas were – Lake Koka (Ethiopia), Masinga Dam (Kenya) and Lake Kyoga (Uganda)
4. Detectability of land cover time changes was demonstrated at the same areas. Two-band composition was used to detect water level difference of selected time horizons. In addition Landsat TM and ETM+ channel 5 data were used to visually compare extents of a Ndolwa pond in years 1986 and 2001. An Arc View shape file achieved through GPS area measurement realized in March 2007 was overlaid to position a part of pond periphery and point at differences in water level changes.

The target of Deliverable 4.3 was to introduce first findings of remote sensing analyses. The work was focused upon basic assessment of the land cover as the essential and almost mandatory subject to begin any remote sensing data-based analysis with. Land cover is the object that is actually 'seen' by the spaceborne (or airborne) sensors. Thus, its assessment is one of the basic remote sensing data analysis tasks. Available information is not limited just to land cover maps themselves. Thematic analysis of land cover is a must in landscape research, monitoring and planning. Through analyzing land cover and its change-over-time e.g. phenology of ecosystems, water quality and/or runoff preconditions can be studied. Land cover knowledge has also become important to indicate and overcome the problems of uncontrolled development of human activities and accompanying deterioration of environmental quality. In the view of remote sensing, land cover assessment is an indispensable base for analyses of environmental processes and problems that must be understood if human environment conditions are to be improved and/or maintained.

First findings and remote sensing analyses had originally been expected to be done for the most of selected BOMOSA plots, within all four ecozones. For these reasons the goals of first remote sensing analyses were as follows:

- o To indicate overall variability of the land cover and distribution of present ecozones.
- o To distinguish an overall land cover indicated by satellite sensors into main structural categories (i.e. water bodies, forest, non-forest vegetation, and bare grounds) and, if possible, at least some sub-categories.
- o To detect and delineate territorial occurrence of distinguished 'land cover classes' in the form of single-class 'land cover masks'.
- o To create an overall land cover map of the main study area of Central Kenya
- o To create land cover maps for environs of selected BOMOSA ponds.

For the purpose of this study there was the 'Central Kenya' digital multispectral data set created through mosaicking relevant neighbouring parts of same-day Landsat-5 and Landsat-7 scenes of 168-060 (Mount Kenya) and 168-061 (Nairobi) acquired on 25.02.1987 and 21.02.2000, respectively.

The main method used for land cover assessment was step-by-step supervised multispectral classification. From the overall map of land cover for Central Kenya, the 1024 x 1024 pixel sized subsets were created for the Kwa Ngei Dam, Lukenya Dam 3, Mairo, Ngeki Dam, Ruthagati and Sagana sites environs. From the multispectral satellite images thematic maps of following land cover classes were derived: water bodies, dense forest, sparse forest and woody plants, non-forest vegetation, bare grounds 1 (mixture of dry and green vegetation), bare grounds 2 (dry vegetation) + clouds and not classified surfaces.

Achievements for task 4.2.2 Second stage RS analysis (M12 – M24)

During the second year the following scene subsets were evaluated – Alagae region (Ethiopia), Lake Koka (Ethiopia), Lake region (Nakuru, Naivasha, Kenya), Bomet region (Kenya), Kisumu region (Kenya), Jinja-Kampala region (Uganda). Water bodies were identified and maps of water bodies were made. Priority regions for BOMOSA scale up were respected.

During period three, model area of Awasa region (Ethiopia) was processed and supplemented by the example of landscape wetness analyses. See Additional deliverable to D 4.8.

Recommendations how to make use of BOMOSA remote sensing method are based on results of processing of different types of satellite data. Future perspectives and application for developing scale up model are drawn in Technical Implementation Plan.

It was essential to verify the results and sensitivity of BOMOSA small water bodies detection method. Verification, based on maps and its integration with GPS technology, enabled to track in terrain small water bodies (smaller than 1ha), identified by BOMOSA method. Main works were held in Machakos and Kisumu area and Kamuli District, with satisfactory results. The field work was slightly limited by the access possibilities to water objects.

Remote Sensing Workshop and Training Course – part 1 (2 to 13 March 2007, Sagana AC, Kenya)

Main goals of the Part 1 of the course were as follows:

- o To provide basic information on the physical and biological nature of remote sensing data, with special attention to the multispectral data provided by Landsat satellites.
- o To provide overview of all major steps on the way from data acquisition to thematic information derivation.
- o To let participants acquire basic skills in digital processing and interpretation of Landsat multispectral data.
- o To encourage participants for applying both remote sensing data and achieved skills on using the data processing tool in their own work within and beyond BOMOSA scope.
- o To make participants acquainted with potentialities, fundamentals and basic functions of Global Positioning System (GPS) technology.

As a training & learning software there was the program called MultiSpec used. This free piece of software continues being developed under collaboration of NASA and Purdue University, Indiana, USA, to support use of Landsat data within the worldwide program on environmental education.

The course was attended by eight participants from all three African countries.

Remote Sensing Workshop and Training Course – part 2 (25 March to 1 April 2008, Debre Zeit, Ethiopia)

Second part of remote sensing workshop was organized in Debre Zeit, Ethiopia prior to BOMOSA mid-term meeting from. Preparation activities included:

- a. Downloading of six LANDSAT scenes of Ethiopia (168-053, 168-054, 168-055, years 1986 and 2000)
- b. Data pre- and processing
- c. Course program preparation
- d. Tutorial material (DVD, presentations consisting of c. 200 slides)

14 participants from the following partner institutions: EIAR (Ethiopia), Egerton University (Kenya), KMFRI (Kenya), DFRU (Uganda) took part. Principles of the developed method for evaluation of water bodies were explained and examples of method application were demonstrated and discussed. The process of satellite image evaluation was trained and inputs for the manual were formulated.

During the second year of BOMOSA project the circumstances supporting continuity in remote sensing analyses appeared. It was necessary to ensure the future possibility of using of remote sensing method. That meant to find other source of easy-accessible satellite data that could be used for small water bodies' detection (See Additional deliverable to D 4.8.). During the field work in October 2008 (documentary film production) negotiation with local authorities and researchers give an impulse for opening new themes. Ugandan Minister of Agriculture, Mr. Fred Mukisa initiated the study

about wetlands in Kamuli region and their potential use for BOMOSA fish farming system. The success of BOMOSA project is highly dependent on water availability in the landscape. The study of Mau forest points out how decrease of total area of tropical forests influences landscape functioning, especially hydrological regime and local climate with all consequences. The hot political topic of Mau forest is becoming a warning example showing what happen with the wetness characteristics and surface temperature in case we remove functional vegetation from the landscape. This topic is actual, especially in these days (August 2009), when the large regions in Kenya (especially in the Rift Valley) suffer from serious drought, resulting in famine threat. Consequently some sites of BOMOSA fish farming system are endangered by shortage of water; some running plots have to stop fish production. This Mau forest study highlights the relations between proper landscape and water management.

Wetland analyses in Kamuli district based on remote sensing data used for BOMOSA and free water restoration

Kamuli district, the region, where first two model BOMOSA plots have been establish, lies within the swampy area of Lake Kyoga. Because of positive acceptance of BOMOSA project in local communities there is an idea to spread the cages-fish farming system to more communities within Kamuli district. Interviewing of local people revealed there used to be many open water bodies, however in the last twenty years many have become overgrown with aquatic vegetation. The aim, supported by Ugandan Ministry of Agriculture, is to use these overgrowing water bodies and wetlands for fish farming and restore free water. In order to get more water bodies for BOMOSA cage fish farming macrophyte vegetation should be harvested and recent sediment partly removed.

The question is where to restore water bodies for cage farming. Remote sensing methods and archive satellite images offer an objective method how to look back. The main task was to detect free water from Landsat satellite images and wetlands, in which water still prevails over macrophytes. Comparison of two Landsat scenes from 1986 and 2001 enables to detect the extent of free water and wetlands and to make change-over-time analyses. It is anticipated that through archive images it will be possible to detect water reservoirs or wetlands, afflicted with overgrowing. The removal of macrophytes from such reservoirs could provide new water resources for fish farming, without any negative effect on water regime of wetlands. Despite the image from Terra Aster satellite only covers part of Kamuli district (vicinity of Kamuli town), the complete the information with data acquired in year 2006.

There are several ways, how to use remote sensing data for evaluation of wetlands in Lake Kyoga region. The first analyses of wetlands can be done through simple RGB image visualization and interpretation. This image can help us to select the areas and sites suitable for foundation and development of new BOMOSA sites. Visualization in MultiSpec software offers possibility to find out the geographical coordinates of selected localities (if the image has been geocoded), followed usage of GPS technology enables to search the proper places in terrain.

The results based on supervised classification of satellite images revealed significant changes in wetland areas and their distribution in Lake Kyoga region. The changes between the years 1986 and 2006 show subsequent decrease of wetlands and water bodies. It seems large areas have been drained and landscape lost water. However the issue of Lake Kyoga hydrological regime is very complicated and ambiguous. The morphology of flat area between Lakes Victoria and Kyoga play substantial role in flooding and wetlands dynamics. Lake Kyoga is very prone to fluctuations of water level and has a quick response to precipitation amount. In addition the rise of water level can be caused by accumulation of floating mats of aquatic vegetation. Because of nearly zero exaggeration, even slight increase of water level of Lake Kyoga can evoke flooding of vast areas. Due to these facts, the extension of wetlands in the area is very changeable and unpredictable.

The aim of this research was not to provide exact and addressed information about localities, where to establish new BOMOSA sites. The main contribution was to introduce the tool and basic methods how to look back in landscape development and what can help to make decisions. However the field verification of the results is essential. Satellite images (water and wetlands mask and multispectral image) can also be used for discussion with local authorities and wetland protection authorities on future up-scaling of BOMOSA fish farming.

For more details see Additional deliverable to D 4.8.

Effects of Mau forest clear cut on temperature distribution and hydrology catchment of lakes Nakuru and Naivasha

The success of BOMOSA project is highly dependent on water availability in the landscape. The study of Mau forest points out how decrease of total area of tropical forests influences landscape

functioning, especially hydrological regime and local climate with all consequences. The hot political topic of Mau forest is becoming a warning example showing what happens with the wetness characteristics and surface temperature in case we remove functional vegetation from the landscape. This topic is actual, especially in these days (August 2009), when the large regions in Kenya (especially in the Rift Valley) suffer from serious drought, resulting in famine threat. Consequently some sites of BOMOSA fish farming system are endangered by shortage of water; some running plots have to stop fish production. This Mau forest study highlights the relations between proper landscape and water management.

The study presents the extent of deforestation in Nakuru and Naivasha region (Rift Valley, Central Kenya) between the years 1986 and 2005 and its effects upon thermal-water characteristics of the landscape. Such changes have immense impact on hydrological regimes of the Rift Valley lakes in central Kenya. Multispectral data from Landsat TM and ETM⁺ and Terra Aster were used to determine dense and humid forests as well as their changes over time. The field observation, realized during “dry” rainy season in October 2008 confirmed evident decline of precipitation and consequent low water discharge from the deforested catchment in the rivers and water level in lakes. Resulting from the satellite images, forest excision on such a large scale as it has been happening in case of Mau forest; induce rapid decrease of humidity, guided by consequent rise of temperature. And not only does on clear-cut areas, where it is most evident, so do in whole catchments where the changes have been undergoing. Remarkable decrease of water discharge and temperature rise on the deforested areas of the Mau forest evidently proves the positive effect of forests in water balance of larger catchments. Consequently it is shown that human activities, and to be concrete water and vegetation management, directly causes the climate change in regional scale.

For more details see Additional deliverable to D 4.8.

Achievements for task 4.2.3 Development of the RS evaluation method (M7 – M24)

Remote sensing task within BOMOSA project was to develop and apply evaluation method to assess potential water bodies for regional development of aquaculture. Processing and evaluation of satellite images seems to be a very practical way of detecting small water bodies. This should enable improved site selection and zoning and lead to better engineering of farms. The RS analysis comprised of stepwise evaluation of Landsat TM/ETM⁺ images, in parallel capacity building of RS competence in the African partner countries (Kenya, Uganda, Ethiopia) and collaborative development of the new evaluation method.

The method developed, had to meet criteria of low-cost, simplicity, universality, high accuracy and reliability. To distinguish small water bodies, from size 1 pixel (30 x 30 meters), we have tested several approaches. From all tested, two have provided satisfactory results – Principal Component Analysis (PCA) and Normalized Difference Snow Index (NDSI). Both complementary variants are based on radiometric enhancement of Landsat data. The principal components method is able to detect water bodies as such and also areas which contain a bigger amount of vegetation (wetland etc.). The method based on the NDSI index can only detect water bodies; however, it is able to detect even straight water streams which are mostly ignored by the first alternative. In addition it has shown that this approach seems to be more universal and is applicable on other satellite data types (eg. Terra Aster, EO-1 ALI). However, in order to gain as complex information as possible about potential water bodies in the area, it is advisable to add up the masks resulting from both alternatives. The method also includes some other procedures of digital data processing. The supporting interpretation is based on color compositions (which are generally considered as a type of radiometric enhancement) and on interactive techniques providing a spectral enhancement of the visualized image. The final stage of the development of the water bodies' mask is the controlled recoding of the image values into the binary form. The method and all the supporting procedures are designed for an open source software system for digital data processing called MultiSpec (Purdue University, Indiana, USA). Its scheme is universal and can therefore be used in commercial software systems.

In order to develop the remote-sensing based evaluation method to assess potential water bodies, three model areas were selected – two in Central Kenya and one in the Kamuli district, Uganda. In these three cases, the work could be supported with findings from field observations.

The method for detecting small water bodies was designed for Eastern Africa and the BOMOSA project. Its universal use and application to other areas cannot be guaranteed. The main constraints of the method are following: The size of the water bodies that can be potentially detected is dependent on spatial resolution of the satellite data (Landsat 0.08 ha). Cloud shadows, very steep slopes and bottoms of canyon valleys are mistaken for water bodies. Another factor potentially distorting the results is thick vegetation. The multispectral satellite systems scan the land cover only and cannot

penetrate below the thick cover of plants. Urban units contain a huge amount of mixels and aerosols in the air which can cause a false detection of water etc.

For more details see Deliverable D 4.8.

Terra ASTER data

The BOMOSA method has been originally proposed for Landsat data. During the project the unexpected circumstances came out. The CSIR Satellite Application Centre (SAC) that used to serve as regional African receiving station had discontinued reception of Landsat 5 data by 19 August 2001. This means that there are no later Landsat 5 data available. As a potential source of new and up-to-date data Terra ASTER multispectral satellite data has been investigated to represent current state of BOMOSA areas. Both approaches of the small water bodies detection – Principal Component Analysis and image rationing (Normalized Difference Snow Index) were tested on Terra Aster data. Processing of five scenes (Machakos, Thika, Sagana, Mailo, Ndolwa areas) has revealed that the method should be applied mainly on Landsat TM/ETM+. The accuracy of the outputs from Aster data is very changeable and in some cases neither of both approaches brings reliable results. Potential future use of Aster data would require development of a new method and approach how to detect small water bodies, suitable for BOMOSA project purposes. E.g. thematic recoding of AST 3N band seems promising and was tested on Machakos area.

However according to latest news from NASA, Terra Aster SWIR detectors are no longer functioning due to anomalously high temperatures. ASTER SWIR data acquired since April 2008 are not useable. This fact unfortunately limits future use of Aster data.

For more details see Deliverable 4.8.

EO-1 ALI data

During the period 3 of the project another possibilities of free satellite data, having the same parameters like Landsat, was investigated. Another data alternative could be ALI sensor on board EO-1. The Advanced Land Imager (ALI) was designed to demonstrate improved Landsat spatial and spectral resolution and has nearly the same characteristics. The scene size is 185 x 37 km, so nearly six times narrower, in a comparison with Landsat and data have been available since 2001 so its important for future perspective. These data are available for free, after registration, from: <http://edcsns17.cr.usgs.gov/EarthExplorer/>. Data are georeferenced in UTM-WGS-84 system and the main disadvantage is that are resampled by cubic convolution. This interpolation method produces slightly sharper and smoother image appearance than the others, keeps the original geographical position, and nevertheless changes the original measured values of image.

Both approaches of small water bodies detection were tested. Because of 16-bit data, Principal component analysis approach could not been used. The NDSI approach, based on thematic recoding of Normalized Difference Snow Index appeared as applicable. Instead of using channels TM2 and TM5 as in case of Landsat data, the formula was adjusted to EO-1 ALI data in following way, with respect to wavelengths of channels:

$$\text{NDSI} = (c4 - c9) / (c4 + c9) * C$$

As a model area central part of Lake Kyoga was chosen. The date of acquisition was on 11 June 2005 and data were gained from the archive of USGS (United States Geological Survey).

See Additional deliverable to D 4.8.

The manual

Complementary material, detailed step-by-step manual, containing exact procedures in MultiSpec, has been finished. Both procedures (image rationing - Normalized Difference Snow Index and Principal Component Analysis), proposed especially for BOMOSA project, have been detailed and demonstrated on the selected model area in Central Kenya (Thika). The manual contains many "Print Screen" illustrations from MultiSpec. All African partners were asked to assess and review the method and manual.

The manual consists of five main chapters:

1. Introduction
2. Small water bodies detection using image rationing (NDSI)
3. Small water bodies detection using Principal Component Analysis
4. Final water bodies mask

5. GPS integration

The manual is expected to be issued by October 2009 and is going to be a part of Technical Implementation Plan.

Achievements for task 4.3 Analyze veterinary aspects and public health (M7 – M24)

Achievements for task 4.3.1 Pathology survey (M7 – M24)

Periodic reviews of scientific literature and databases have been carried out to collect and update information about fish pathology with particular reference to tropical environments and freshwater fish species farmed in East Africa.

Veterinary field activities have been conducted in March 2007, October 2007, July 2008, September-October 2008, aimed at monitoring the health status and parasitic agents of Tilapia and, at minus extent, of African catfish from several BOMOSA sites (plots and hubs).

A total of 982 tilapias - 685 from Kenya, 222 from Uganda and 75 from Ethiopia - were sampled and subjected to anatomo-pathological and parasitological examination. In some cases, bacteriological exams were carried out and infected tissues were fixed in 10% buffered formalin for histology. During the survey, fish from different environments (258 from open water reservoirs, 445 from ponds and 279 from BOMOSA cages) were sampled in order to evaluate the factors which could influence the diffusion of pathogenic agents and outbreak of diseases. Quantitative data, such as prevalence, intensity and abundance, and qualitative data have been evaluated, together with the main abiotic and biotic risk factors identified as relevant for veterinary and public health aspects in tilapia aquaculture.

On the basis of the results of the veterinary monitoring activities, the parasitofauna didn't show remarkable differences between wild and farmed (in cages and earth-based ponds) fish, except for protozoan ectoparasites found mainly and with high infection intensity only in farmed tilapias.

At this regard, parasitic infections due to protozoan ectoparasites are influenced by poor water parameters (pH, Ammonia, low water exchange, high organic load, etc.) and husbandry conditions (overcrowding, etc.), requiring attention to these factors during environmental monitoring programme. Biomass density will be an important factor to assess also with reference to monogenean (dactylogyrids and gyrodactylids) infections.

Concerning parasitic infections due to heteroxenous parasites, detected in all the sampling sites, biotic factors such as presence of invertebrates and piscivorous birds could represent important risk factors and should be evaluated and estimated during the environmental monitoring programs of the BOMOSA sites. In particular herons, cormorants and pelicans have been found massively infected by Clinostomatids, Contracaecum nematodes and Gryporhynchid cestodes during this survey.

The causes of mortality observed in fingerlings during/after transportation have been referred to opportunistic bacterial infections triggered by stressful conditions to be prevented with simple technical optimization measures to be applied during the transportation phases. Bacterial problems referable to primary pathogens frequently reported in tilapias, such as *Streptococcus iniae*, have not been individuated in the examined fish. Neither lesions nor microscopical findings referable to *Aphanomyces invadans*, aetiological agent of the Epizootic Ulcerative Necrosis, OIE notifiable disease, have been detected during the survey in the examined tilapias.

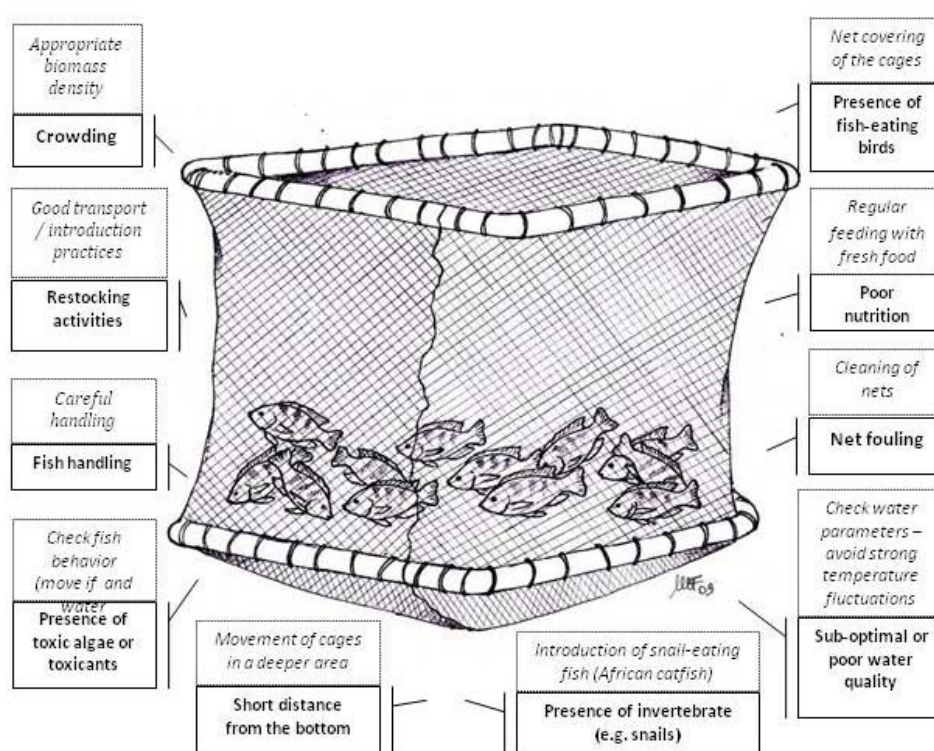
In general, on the basis of the results of the veterinary activities, the following risk factors and related preventive/control measures (underlined) can be listed:

- overcrowding and poor water quality parameters can predispose to parasitic infections due to protozoan and monogenean ectoparasites in hatchery and cage-farmed fish; at this regard, the maintenance of good water parameters and low biomass density are important methods of prevention for this infections;
- invertebrates (gastropods, crustaceans, ecc.) are often intermediate hosts of heteroxenous parasites (cestodes, nematodes, digeneans, acanthocephalans, ecc.) and their presence is necessary for the transmission of these parasites to fish, mainly in natural water bodies but also in earth-based farming ponds; at this regard, biosecurity actions aimed at reducing or avoiding the presence of these invertebrates (e.g. introducing a congruous number of siluroid catfish) could be useful in limiting the colonization and spreading of some parasitic infections;
- piscivorous birds are definitive hosts of heteroxenous parasites (cestodes, nematodes, digeneans, ecc.) harmful to fish, both farmed and wild; furthermore, they can spread several infectious pathogens among water bodies and within fish populations. At this regard, their

presence should be reduced as much possible in order to minimize the contamination of the farming systems (e.g. protecting by nets the farming area when feasible);

- infections by opportunistic bacteria such as *Acinetobacter* sp., *Chryseobacterium* sp., *Pseudomonas* sp., *Aeromonas* sp., commonly associated to integrated farming systems, and Flavobacteriaceae, commonly present in skin and gill mucus of fish, can be triggered by stressful conditions and mechanical lesions respectively. At this regard the improvement of stocking and transportation practices (e.g. reducing the biomass density in hatchery tanks and in transport bags, starving the fingerlings for at least 24 hours before transportation, using 0.5-1% NaCl in transport water, carrying out a careful acclimatization at the arrival to the plot, etc.) may prevent the mortality outbreaks without using antibacterial treatments;

The risk factors which may influence the onset and outbreak of parasitic and bacterial diseases in BOMOSA plots are schematized in the following figure. Preventive and control measures should be aimed to avoid or reduce the impact of these risk factors on the farmed tilapias.

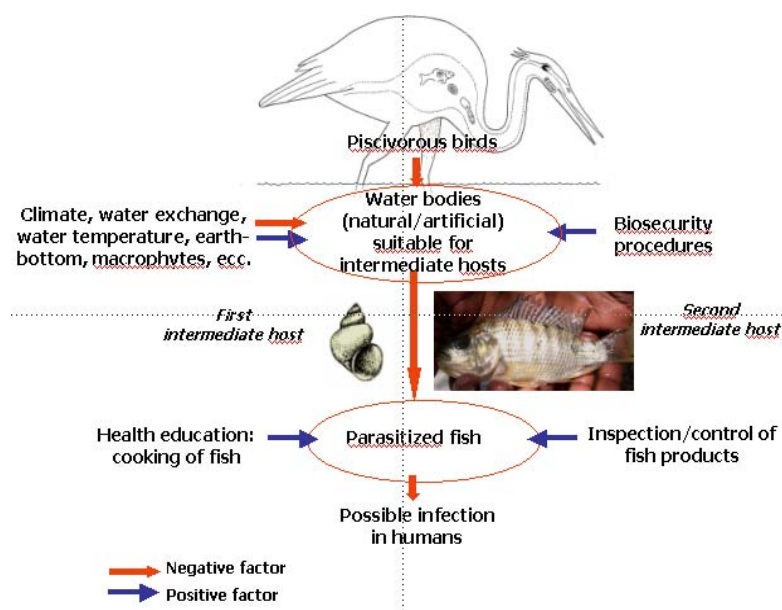


Main risk factors (☐) which may influence disease outbreaks in BOMOSA cage systems and attendant recommendations (☒).

The overall results of the parasitological survey have been published on a national peer-reviewed journal.

Among the findings collected during the two-years monitoring activities carried out in Kenya, Uganda and Ethiopia, the following public health aspects were individuated:

- among parasites, only Clinostomatid digeneans and *Contracaecum* nematodes may represent a risk factor for humans when raw or slightly cooked parasitized fish are eaten. At this regard the cooking of the fish easy inactivate the parasite, representing an useful individual control method. In the figure below the factors influencing in a positive/negative way the completion of the life cycle of Clinostomatid digeneans and their transmission to humans are schematized.



Factors influencing in a positive/negative way the completion of the life cycle of Clinostomid digeneans and their transmission to humans

Morphological and molecular studies have been applied to the survey of Clinostomid parasites recovered in Kenya, allowing the publication of a scientific paper on an international peer-reviewed journal.

All the results are reported in detail in Deliverable D4.7.

Achievements for task 4.3.3 Aspects of veterinary and public health for the environmental monitoring programme (M13 – M18)

On the basis of the results of veterinary monitoring activities carried out during the first 18 months of the project, a list of the main abiotic and biotic risk factors involved in the determinism of veterinary and public health aspects of tilapia aquaculture in BOMOSA sites was elaborated and delivered to give inputs to the Environmental impact monitoring programme (task 6.4).

Achievements for task 4.4 Analyze current aquaculture legal and regulatory framework and formulate recommendations (M6 – M24)

Achievements for task 4.4.1 Evaluate existing aquaculture institutional environment (M6 – M18)

A wide collection of legal and policy documents concerning aquaculture institutional environment (water management and ownership, environment, veterinary and public health aspects, institutional arrangements, etc.) was carried out from Kenya, Uganda and Ethiopia to assess the existing regulatory framework on aquaculture and formulate appropriate recommendations for its implementation. Furthermore, international and African overarching policy documents have been collected and taken into consideration for a better understanding of actual and future development of the institutional framework on aquaculture in Kenya, Ethiopia and Uganda.

All the collected documents have been used to write up the Deliverable D4.6 in cooperation with African partners. In the D4.6, the documents have been organized in a main section, *Review of Legal and Policy Documents*, in which legal and policy documents, and institutional arrangements, are specifically referred to Kenya, Ethiopia and Uganda. Legal documents and institutional arrangements are subdivided in three macro areas, such as *Fisheries and Aquaculture*, *Environment and Water Resources* and *Animal (Fish) Diseases, Food Safety and Public Health*, while policy documents are of general concern and not subdivided in specific topics. Some organization charts have been provided for the Institutional arrangements in order to better illustrate some institutional relationships. In the final chapter "*Main international and African policy documents*" some documents of common interest for African continent are also listed.

Achievements for task 4.4.2 Develop recommendations for new aquaculture institutional environment (M12 – M24)

On the basis of the reviewed regulations, policy documents and proclamations, some specific comments and recommendations (in italic) on aquaculture institutional environment existing in Kenya, Ethiopia and Uganda have been elaborated, as schematically reported below.

Fisheries and Aquaculture

- aquaculture sector appears underpowered if compared to its potential and most of the policy documents and intent declarations for a strong input on fish farming remain on the paper; this could be an index of low priority of Aquaculture for institutions. *Nevertheless the importance given to aquaculture in several national and overarching African Poverty Eradication Plans, in the three countries the amount of policy documents and institutional arrangements specifically targeted to aquaculture seem to be widely not homogenous, with an increasing attention to this sector in Kenya and Uganda and a decreasing interest in Ethiopia despite the great potential of this country;*
- a large-scale aquaculture is still far to start with the exception of hatcheries and fingerlings production, but standardization of feeding and fish production procedures is lacking; furthermore the lack of adequate infrastructures for fish movement/trade and fish products conservation, and the difficult access to the market for local people are main threats for aquaculture development in a large scale; *an efficient policy of infrastructure improvement may represent the starting point to facilitate the market expansion, farmed fish production included; BOMOSA integrated farming systems are based on a small-scale production at local community level and could represent a good first answer to the fish demand on the local markets.*
- the presence of too many competent authorities without a coordination create a confused situation for fish farmers and stakeholders; the poor information exchange between competent institutions and stakeholders has hampered aquaculture development strategies affecting both policy makers and investors; *collaboration between different authorities working directly or indirectly on the same topic, i.e. aquaculture, is basilar to better define all the frameworks in which aquaculture will move in the future;*
- constraints on aquaculture can take many forms but entrepreneurs encountered the main constraints when they want to start an aquaculture activity or expand an already functioning aquaculture enterprise. One of the most important is microeconomic constraint (or access to capital assets); *these problems could be partially solved through the introduction of economic incentives and disincentives, such as for examples fiscal reforms and micro-credit facilities for small enterprises. Actually the promising growth of African aquaculture is due to the inflow of foreign capital and expertise in aquaculture ventures that supply overseas markets and to the growing public support for aquaculture.*

Environment and Water Resources

- aquaculture activities are suspected to have some environmental impact to water bodies; it is important to evaluate the impact of BOMOSA cages on the environment, depending on the level of production (biomass) and magnitude of the farming system. The up scaling of the BOMOSA system should fulfill the minimum requirements and abide by provisions included in the Environmental Impact Assessment prescriptions provided by Kenya, Ethiopia and Uganda. The local communities will actively oppose any activities that are seen to interfere with their drinking water. *As shown by the environmental data collected in WP4, BOMOSA technology is environment friendly and causes low impact or no damage at all to the water bodies. The BOMOSA system uses a volume-low density type of cage that has little or no effect on the quality of water. On top of this, an environment monitoring plan will be developed for each plot to monitor the quality of the water body and the catchments activities before and during the fish culture and harvesting. It is important to put in evidence that the water bodies where BOMOSA systems are located are not sources of drinking water.*
- water bodies such as lakes, rivers and reservoirs are owned by the state in Ethiopia, whereas there are both state owned and privately owned water bodies in Kenya and Uganda; the BOMOSA systems should take into consideration the different scenarios of land and water ownership and uses. *BOMOSA is mainly based on establishing schemes on water bodies, seen to be favorable in terms of location, physical conditions, as well as use and ownership conditions. It is therefore important to encourage the technology on water bodies owned by the community for the mutual benefit of the society.*
- private plots in community or state owned water bodies lead frequently to conflicts of usage which are in many cases very difficult to resolve; *private ownership is also encouraged for*

BOMOSA plots and needs to be encouraged and supported to promote individual entrepreneurship. The water bodies recommended for BOMOSA plots especially at community and state ownership levels are under other uses such as watering animals or providing water for irrigation. It is therefore paramount that proper education is carried to the communities where the benefits and disadvantages of fish farming are explained and concurrence sought before BOMOSA plots are established;

- *the role of community groups (organized as water resources users association) seems to take moreover increasing importance in the management of water resources, giving the opportunity to appoint committees of governance (Ministry, region and local authorities) and not governance (representative from farmers, pastoralists, business community, etc.) people. Such system as proposed in the Kenyan Water Act gives apparently restricts water rights to a small section of the community, essentially property owners. Poor rural communities are unable to meet requirements for obtaining a permit, mainly land ownership, are in this way marginalized. An enforcement of the local component in the Water Management committees could be a key factor for a collective involvement of the community in making decision. The land ownership around water bodies and its relation to the public water access by all the community need to be better and clearly regulated so that the community investment in the water management will be more active.*

Animal (Fish) Diseases, Food Safety and Public Health

- *lack of national legal frameworks on fish diseases in order to improve health and productivity of farmed fish, avoid the spread of disease, guarantee the safety of aquaculture fish products, prevent public health aspects and avoid possible environmental impacts; the existing policy/legal documents cannot therefore adequately prevent entry and spread of exotic aquatic animal pathogens; are not adequate for control fish diseases in the country; and nor can the policy be implemented as it's implied and not direct; Kenya, Ethiopia and Uganda are members of the Office International des Epizooties (OIE)/World Organization for Animal Health and they should follow the recommendations presented in the Aquatic Animal Health Code. Specific normative will be produced in each country taking into account the specific situation on fish health, and food (fish) safety for human consumption.*
- *the knowledge on the current situation of sanitary status of fish in the three countries is poor and few Research Institutions are actually competent for fish diseases; improvement of the knowledge on fish pathogens/diseases of aquatic animals, and their impact in the wild and under farming conditions. Furthermore the adoption of the OIE Manual of Diagnostic Tests for Aquatic Animals and the capacity building of specialized reference laboratories able to apply these tests are strongly necessary for the next future. BOMOSA Vet activities during WP 4 allowed to delineate a first sight on the sanitary status of farmed fish and its relation with aquatic wild environment in the three countries;*
- *many diseases outbreaks and low efficiency in fish productivity are related to not optimal or sub-optimal management practice by farmers; improvement of farmers' knowledge on the best management practice for transportation, handling, stocking of fish in order to avoid stressful condition that could affect fish health/productivity; assessment of standards methods for monitoring of fish involved in movements to avoid the spreading of diseases and to optimise the fish production in the final destination plots; BOMOSA manual will try to furnish to the fish farmers some practical suggestion to better follow their farming systems. A first approach of health education will be given in the BOMOSA manual to the fish-eating community leaving in areas to make all precautions to prevent the accidental transmission of pathogens by eating spoiled/parasitized fish. Inspection/control standardized methods of fish products for the prevention of possible infections in humans are necessary;*
- *sanitary and phytosanitary standards in aquaculture are not adequately developed; the Agreement on the Application of Sanitary and Phytosanitary Measures by World Trade Organization sets out the basic rules for food safety and animal and plant health standards. It allows countries to set their own standards. But it also says regulations must be based on science. Research Institutions are often marginally involved in making decision even if scientific knowledge should play a key role in standardization of methods for fish safety and quality;*
- *on the basis of FAO/WHO advices and recommendations, Kenya, Ethiopia and Uganda are members of the Codex Alimentarius Commission and have established National Codex Committees (NCC) and National Codex Contact Point (NCCP), answering to the FAO/WHO request. During the last decade, the fish industry has been strongly assisted to develop the capacity to meet the safety requirements of the national/international market, but few regulations*

have been implemented in order to apply a throughout sanitary control of regional/local aquaculture production. *An enforcement of regulatory requirements concerning hygiene, safety and quality of aquaculture and fishery products standards should be managed; furthermore, specific educational programme on safe consumption and preservation methods of fish products, especially in areas such (i.e. Awassa Lake district, Ethiopia) where tilapia are consumed raw, should be planned in order to avoid possible public health implications.*

The sustainable development of aquaculture productions in these countries require more effort to implement and strengthen the legal framework on fish diseases, as well as the correct utilization of disinfectants and therapeutical agents, in order to: improve health and productivity of farmed fish; avoid the spread of disease; guarantee the safety of aquaculture fish products; prevent public health problems; avoid possible environmental impacts.

Lack of adequate knowledge of fish pathogens, diseases of aquatic animals; lack of information and data on the occurrence and impact of disease/parasites/pests aquatic organisms both in the wild and culture conditions are critical problems. One of the most important risk factors for the spread of diseases is the transfer of alien fish species, which is strictly forbidden in all the three countries. The BOMOSA fish farming system is based on transfer of fingerlings only from the hubs to the plots within a national/regional production net. The fish used for this technology are mostly indigenous ones such as Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*). However, there are rules which prohibit the transfer of even live indigenous fish from one regional water body to another regional water body with out a written permit obtained from the competent Authority.

A periodic monitoring on the sanitary and health of fish transported is strongly recommended to avoid the spread of fish diseases and optimise the fish production. The results of the survey on veterinary and public health aspects conducted in Kenya, Ethiopia and Uganda (see Deliverable 4.7) showed that there are several parasites infecting fish and that some bacterial disease outbreaks may occur in some BOMOSA sites mainly under stressful conditions.

The main risk factors causing parasitic and bacterial outbreaks in BOMOSA sites have been observed so that preventive strategies and best management practices should be developed to reduce or prevent the risk (see BOMOSA Manual and D4.7). Some parasites could be transmitted to humans if infected fish products are under cooked or eaten raw. Except in some districts in Ethiopia (e.g. Lake Awassa area), tilapia are consumed well cooked, ensuring the inactivation of the parasites. Also the hot-smoked fish processing ($\geq 60^{\circ}\text{C}$) can easily inactivate the parasites. Generally, health education should be given to the community at all level to prevent the transmission of pathogens and parasites fish. Health education and inspection/control of fish products are key-factors for the prevention of possible infections in humans.

Comments and recommendations have been reported in detail in the Deliverable D.10 and have been used to give an input to TIP (WP7).

3.4.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 4.1 Analyze environmental data from the prototype Kenyan BOMOSA plots (M0 – M6)

There are no deviations to be reported for this task.

Deviations from task 4.2 Develop and apply a Remote Sensing (RS) based evaluation method to assess potential water bodies (M0 – M24)

Deviations from task 4.2.1 First stage RS analysis (M0 – M12)

No deviations from the plan.

Deviations from task 4.2.2 Second stage RS analysis (M12 – M24)

During the second year of BOMOSA project the circumstances supporting continuity in remote sensing analyses appeared. It was necessary to ensure the future possibility of using of remote sensing method. That meant to find other source of easy-accessible satellite data that could be used for small water bodies detection. During the field work in October 2008 (documentary film production) negotiation with local authorities and researchers give an impulse for opening new themes. Ugandan Minister of Agriculture, Mr. Fred Mukisa initiated the study about wetlands in Kamuli region and their potential use for BOMOSA fish farming system. The success of BOMOSA project is highly dependent on water availability in the landscape. The study of Mau forest points out how decrease of total area of tropical forests influences landscape functioning, especially hydrological regime and local climate with all consequences. The hot political topic of Mau forest is becoming a warning example showing what happen with the wetness characteristics and surface temperature in case we remove functional vegetation from the landscape. This topic is actual, especially in these days (August 2009), when the large regions in Kenya (especially in the Rift Valley) suffer from serious drought, resulting in famine threat. Consequently some sites of BOMOSA fish farming system are endangered by shortage of water; some running plots have to stop fish production. This Mau forest study highlights the relations between proper landscape and water management.

Therefore Additional deliverable to D 4.8 supplementary studies using remote sensing has been worked out.

Deviations from task 4.2.3 Development of the RS evaluation method (M7 – M24)

Because of high cloud cover during rainy season and absence of relevant data, it was not possible to process and compare images from dry and wet season. Stopping of Landsat data acquisition for Africa region in 2001 limits their future use.

Deviations from task 4.3 Analyze veterinary aspects and public health (M7 – M24)Deviations from task 4.3.1 Pathology survey (M7 – M24)

No deviations.

Deviations from task 4.3.2 Insect borne disease survey (M13 – M24)

This part has not been evaluated.

Deviations from task 4.3.3 Aspects of veterinary and public health for the environmental monitoring programme (M13 – M18)

No deviations.

Deviations from task 4.4 Analyze current aquaculture legal and regulatory framework and formulate recommendations (M6 – M24)Deviations from task 4.4.1 Evaluate existing aquaculture institutional environment (M6 – M18)

No deviations.

Deviations from task 4.4.2 Develop recommendations for new aquaculture institutional environment (M12 – M24)

No deviations.

3.4.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 4.01	Synthesis of baseline environmental data from existing BOMOSA plots	WP 4	2007-03-31	2007-03
D 4.02	Short report on first three „priority regions	WP 4	2007-03-31	2007-04-04
D 4.03	Basic evaluation method and first findings (report and maps) using RS evaluation	WP 4	2007-09-30	2007-11-12
D 4.04	First report of vet. and public health aspects (results of surveys and recomms.)	WP 4	2007-09-30	2007-10-05
D 4.05	List of vet. and public health aspects for the env. monitoring programme	WP 4	2008-03-31	2008-11-13
D 4.06	Report on existing aquaculture institutional environment in Eastern Africa	WP 4	2008-03-31	2008-11-13
D 4.07	Scientific report of vet. and public health aspects (results of surveys and recomms.)	WP 4	2008-09-30	2008-11-13
D 4.08	Final evaluation method and first findings (report and maps) using RS evaluation	WP 4	2008-09-30	2008-11-13
D 4.09	Final RS evaluation method documented in a manual	WP 4	2008-09-30	2008-11-13
D 4.10	Recommendations for aquaculture institutional environment in Eastern Africa	WP 4	2008-09-30	2008-11-13

3.4.6 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 4.1	Baseline environmental data from existing BOMOSA plots summarized	WP 4	2007-03-31	2007-04	EIAR
MS 4.2	Basic RS evaluation method and first report of vet. and public health aspects complete	WP 4	2007-09-30	2007-10	EIAR
MS 4.3	Vet. and public health aspects for the env. monitoring programme listed and existing aquaculture institutional environment described	WP 4	2008-03-31	2008-03-31	EIAR
MS 4.4	WP 4 Scientific reports completed as an essential input to establishing the Technology Implementation plan in Task 7.5	WP 4	2008-09-30	2008-09-30	EIAR

3.5 WP 5 Low protein, by-product fish feeds, resource development, feed processing and feed economics

To be edited by WP leader according to the requested structure

Responsible: **MU**

Work package duration:

Workpackage start	2006-10-01
Workpackage end	2009-03-31

3.5.1 Workpackage progress overview

A huge amount of various by-products was analysed on the nutrient contents, further developed for fish feeds and tested on their acceptance in many independent field studies. A first step in this project was to evaluate the accessibility of possible feed ingredients and their costs. Information of all three countries were saved in a data base, containing major information on feed ingredients, regions of availability, seasonality, costs and quality variations for example. In each country a so-called hub diet was formulated, by using standard components typical for aquaculture.

Simple feed processing and dispensing devices were monitored and modified for the usage in the hubs and plots. Shelf life of feeds was prolonged by improved storage technology of the feed. Feedstuffs, which were only available in special seasons, were ensiled and therefore easily usable. With month 18 diets, made of locally available by-products which had best results in analysis, were tested in growth performance experiments.

3.5.2 Objectives and starting point of work at beginning of reporting period

Fish production in Sub-Saharan Africa commonly occurs in semi-intensive culture systems where they partly depend on natural pond productivity in addition to supplementary feeding with any artificial feed supplement. However, cage culture is relatively new in the proposed target countries and thus, quantitative and qualitative aspects of the feeds needs to be evaluated and determined. Fish production is not only determined by feed quality, but also by feeding rates and frequencies. Feed is among the most costly items in fish production, contributing to more than 50% of the total operational costs. Thus for successful and economical fish production, a thorough investigation on cost-effective diets will therefore be required. Furthermore, there is need for evaluation of effective means of packaging, storing (incl. assessment of shelf life) and dispensation of the feed. This work package will concentrate on evaluating locally available ingredients and combinations thereof for cage and semi-intensive production of indigenous fish species (Nile Tilapia and African Catfish) and the development of devices for processing and dispensing the feeds.

The specific objectives of the work package are:

- Identify locally available ingredients, estimate their feeding value and formulate practical diets for the selected species and different eco-zones.
- Analyze the cost-effectiveness of the feed components and formulated diets for different eco-zones.
- Develop optimized feed processing and dispensing devices using appropriate technologies
- Evaluate nutritive quality of different feed materials for aquaculture use
- Formulate suitable feed diets for use in different plots and eco-zones.

3.5.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 5.1 Survey of available feed ingredients and their costs (M0 – M12)

Existing data was formatted to fit in the data base design. A data base for feed was constructed in all the three countries with responsible contact persons. This data base contains data of locally available feed ingredients arranged according to country, region or plot in which feed ingredient was found, level of protein, ether extracts and soluble carbohydrates. Other information incorporated included seasonality of availability, cost and quality variations. Several data gaps were identified during the filling in of the data base. Some of these gaps were filled in with existing data collected from literature. Issues that required further addressing in feed formulation and production were identified. A total of 48 (Kenya), 14 (Uganda), 16 (Ethiopia) feedstuffs were analyzed from animal and plant sources. Some of these included:

Kenya	Ethiopia	Uganda
▪ Cereal brans ▪ Freshwater shrimps ▪ Omena fish ▪ Hydrolysed feather meal ▪ Mexican sunflower ▪ <i>Galinsoga Parviflora</i> ▪ Lucerne seed ▪ Sesbania seed ▪ French bean ▪ Tomato peels ▪ Onion leafs ▪ Avocado leaf ▪ Breweries waste ▪ Seed cake (Cotton seed, sunflower) ▪ Fishmeal - Mukene ▪ <i>Lates niloticus</i> skeleton! ▪ Leaves: Cassava, Sweet potatoes, papaya peels, Beans, Arrowroot, mexican sunflower, Omenta) ▪ Off cuts, potato & banana peels ▪ Local brew (malwa) dregs ▪ chicken offals, ▪ slaughter house waste, kitchen left overs	▪ Catfish & tilapia fillet remains ▪ Garra fish spp. ▪ Sorghum beetle ▪ Lathyrus pea (Vetch) coat ▪ Beans coat ▪ Peas coat ▪ Lentil pod ▪ Brewery by-products ▪ Tuffs remains ▪ Floor mill leftover - (Teragi) ▪ Cotton seed cake ▪ Wheat bran	▪ Brans (Maize & Rice)

Design criteria for feed selection for all countries

Criteria for feed selection were developed for all countries. The selection criteria was based on: local availability and abundance, level of crude protein, level of crude fibre and total ash content, cost per nutrient, least competition with other users and absence of anti-nutritional factors.

Identify and analyse new feed ingredients for all eco-zones in the different countries

The areas surrounding selected sites for BOMOSA plots were surveyed for potential feed ingredients. The plot sites were visited and the findings were recorded. In Kenya the surveyed sites include: Harambee, Kondamet and Damside in the Lake Victoria region; Ngeki, Kwa Ngei and Lukenya in Machakos; Ruthagati, Sagana and Mailo in Mount Kenya region. In Uganda, the sites included areas surrounding Nakasongola, Kasolwe and Ndhola while in Ethiopia Yemlo and Alage were visited. New feed ingredients were identified in all the target eco-zones in the three countries. Proximate analyses of all collected feed ingredients were conducted for crude protein, ether extracts, crude fibre, ash content, moisture content and nitrogen free extracts. Some of the results are shown below:

Identified feed ingredients for HUB diet for Kenya and Uganda

In Kenya and Uganda freshwater shrimps (*Caridina nilotica*), Cotton (*Gossypium* sp) seed meal and wheat bran (*Triticum aestivum*) were selected and used for the formulation of the HUB diet.



Figure 17: Freshwater shrimps (*Caridina nilotica*) a by-product of Omena (*Rastrineobola argentea*) fishery



Figure 18: Cotton seed cake a by-product from textile industry, rich in protein



Figure 19: Wheat bran (common cereal bran in Kenya and Uganda)

In Ethiopia leftovers from posho mill was used in formulating the hub diet.



Figure 20: Left overs from Posho mill, Alage (BOMOSA site)

UGANDA:

Identified possible fish feed ingredients in Uganda and their economic value:

Ingredient	Value (USD \$)
Maize bran	0.1/kg
Rice bran	0.001/kg
Sweet potatoes off cuts	free
Cassava off cuts	free
Mukene fish (R. argentea)	0.45/kg
Nile perch skeletons	0.3/kg
Local brew (malwa) dregs	free
Plant leaves – beans, soya, cassava, potatoes, Mexican flower	free
Chicken and Pig offals	free
Cow blood from slaughter houses	free

*Exchange rate: USD 1\$ = UShs 2200/=



Figure 22: Breweries waste was introduced as fish feed blend

Achievements for task 5.2 Development of feed processing, storage and dispensing devices (M6 – M18)

Working closely with partners in the three countries field tours were conducted to assess the existing feed processing equipment in use. Inexpensive prototype mixers, hand mills and pelletizers were fabricated or modified for fish feed production for the hub and plots.



Figure 23: Meat mincer



Figure 24: Feed production



Figure 25: Feed packaging

New feeds for the hubs and plots were formulated from the ingredients identified in task 5.1. Trials on optimized packaging have been carried out to improve storage and increase shelf life. The feeds were packaged into perforated plastic bags of different sizes for storage. Quality of the packaged feed was determined from time to time to investigate the efficacy of the new packaging.

A semi automated non-electronic feed dispenser was developed for fish feeding in the plots. The feed dispensers were fitted with a clock-work and a conveyer belt which enables the feed to be administered at set times. Apart from the clock-works which were obtained from Vienna (Austria) the rest of the material, including the plywood for holding the feed, were sourced from the local market.



Figure 26: Feed dispensers

Silage production

Feedstuffs that are abundant and rare in specific periods were processed into silages. Leaves containing small amounts of stems were coarsely chopped using the chopper (equipped with an engine). The chopped material was divided into two batches: One batch was packed into plastic bags, which were placed into a 10 l-plastic bucket prior to being filled with the plant material. The plant material was compressed by hand and the air sucked out of the bags using a normal house vacuum cleaner. The bags were closed as tightly as possible using rubber straps. The buckets were closed with lids. To the second batch of chopped about 1 l of molasses diluted with tap water (1:1 ratio, stirred properly) was added. The chopped leaves and molasses were mixed manually in order to give a fairly homogeneous material which was then treated as described above. The silage with molasses was stable in nutritional quality for six months while the batch without molasses degraded within the first week after ensiling.

Achievements for task 5.3 Quality and performance of selected feeds (M9 – M24)

Different feed materials for aquaculture were assessed for their nutritive quality in Kenya, Uganda and Ethiopia. Non-conventional feedstuffs from this study showed that Leaves from Sweet potato, Cassava, Brewery wastes and Mexican sunflower were found to have high protein.

This estimation was mainly based on Nutrient content (proximate analysis).

The feasibility of removing ANFs was also pursued.

Preliminary proximate composition was conducted and the results are presented in the tables below:

Table 2: Proximate composition of different potential feed ingredients ($\bar{x} \pm s$); *DM=Dry matter, CP=Crude Protein, EE=Ether Extracts, CF= Crude Fibre, NfE=N-free Extracts

Product	No of samples	*DM	CP	EE	CF	NfE	Ash
plant parts and by-products		g/kg	g/kg DM				
Arrow root leaves	3	903±2.6	335±1.0	85±1.5	106±4.6	381±2.1	93±2.3
Banana peel	4	901±2.1	72±1.7	79±1.3	113±2.6	627±1.7	109±2.8
Banana stem	4	926±1.0	100±1.8	50±2.2	441±1.7	205±3.5	205±4.5
Banana leaves	4	899±1.0	170±1.8	127±1.4	241±1.8	337±1.3	124±3.6
Boiled tea leaves residue	4	919±1.7	279±2.2	149±1.3	148±1.7	377±1.9	47±1.9
Cassava leaves	5	919±3.6	308±4.8	86±4.1	156±4.0	368±2.1	82±5.2
<i>Leucaena</i> leaves	3	929±1.0	280±1.5	71±1.5	158±2.1	391±1.0	99±2.0
Papaya peel	4	839±1.3	179±2.4	18±3.1	194±2.2	456±4.0	154±3.4
Papaya leaves	4	903±2.9	282±5.0	105±2.5	130±1.3	329±3.3	154±1.2
Pyrethrum whole	2	890±0.7	150±1.4	45±0.7	282±3.5	420±1.4	104±4.2
Sweet potato leaves	5	892±1.6	353±3.6	43±3.7	105±3.6	388±1.1	104±3.6
Water fern, whole	4	888±2.4	232±1.9	49±0.8	302±3.6	239±1.3	179±3.4
Water hyacinth, whole	2	895±1.4	133±4.2	18±1.4	260±2.8	407±4.2	188±3.5
selected seed meals							
Cottonseed cake	5	893±2.0	388±7.2	107±1.0	249±4.5	192±2.6	63±4.6
Mango seed embryo	2	907±1.4	70±0.7	97±1.4	37±0.7	771±2.1	24±1.4
Papaya seed meal	4	945±1.7	264±21	316±1.3	119±1.0	203±1.6	98±1.3
Sunflower seed cake	5	929±0.4	259±0.1	54±0.8	368±0.2	266±0.8	51±0.1
selected cereal brans							
Maize bran	5	894±3.0	118±4.6	107±2.7	55±0.7	691±1.9	29±1.3
Rice bran	5	923±4.2	70±3.8	41±1.6	309±2.4	349±3.5	229±2.2

Wheat bran	5	882±1.6	171±6.2	58±2.3	127±2.3	582±6.9	60±2.6
selected seed husks							
Coffee husks	4	893±1.9	47±1.8	36±0.6	383±2.6	418±3.6	115±2.8
Coffee pulp	4	874±1.9	172±2.2	60±1.3	281±2.2	320±1.9	168±1.3
Cotton husks	3	906±4.9	173±4.4	55±1.0	587±1.5	153±1.5	36±0.6

Formulation of suitable feed diets for use in different plots and eco-zones was achieved as follows:

Table 3: Formulation diet composition - Ethiopia

Feedstuffs	% inclusion	ingredient	% protein	% lipid	% crude fibre
Breweries waste		41.6	10.5248	2.496	1.664
Cotton seed		48.4	17.3756	3.2428	3.4364
Wheat bran		10	1.4	0.65	1.6
TOTAL		100	29.3004	6.3888	6.7004

Table 4: Formulation diet composition - Kenya

Feedstuffs	% inclusion	ingredient	% protein	% lipid	% crude fibre
Freshwater shrimps		12.0	7.6	0.7	0.5
Cotton seed cake		44.4	15.9	3.0	3.2
Wheat bran		43.6	6.1	2.8	7.0
TOTAL		100	29.6	6.5	10.6

Table 5: Formulation diet composition – Uganda

Ingredient	% inclusion	% protein	% lipid	% crude fibre
Diet ONE				
- Maize bran	35	11.10	13.07	4.26
- Cotton seed cake	53	29.13	8.06	17.39
- Mukene (<i>R.argentae</i>)	12	26.70	2.04	0.54
Diet TWO				
- Rice bran	35	12.80	21.26	5.86
- Cotton seed cake	53	29.13	8.06	17.39
- Mukene (<i>R.argentae</i>)	12	26.70	2.04	0.54

Acceptance of feed by fish is clearly different for different feedstuffs depending on texture, silage quality. The highest acceptance was for breweries wastes.

In Ethiopia:

Dr. Munguti from KMFRI visited Ethiopia in July 2008 as planned in the Kisumu meeting held in June 2009. He shared his expertise on fish feed and managed to formulate feed. The feed formulated was composed of the following ingredients: a) wheat bran b) breweries waste and c) cotton seed.



Figure 27: Breweries waste



Figure 28: Acacia spp.



Figure 29: Fish offals





Figure 30: Feed preparation

A study was conducted to investigate the possibility of deliberate manipulation by whole salers and retailers. The nutritional value of ingredients was found to change throughout supply chain and it was established that between the landing site or factory and the shop, there is a lot of adulteration of fish feeds.

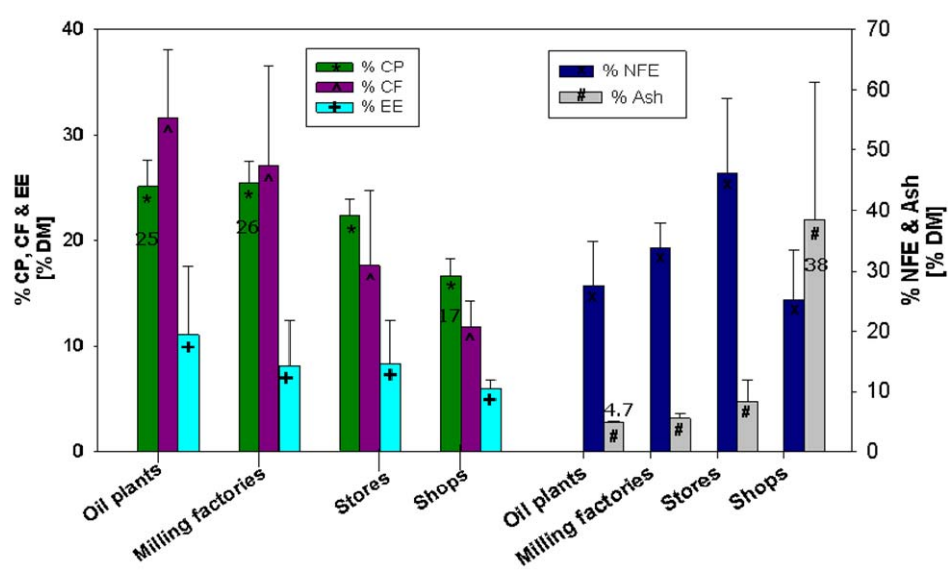


Figure 31: Composition of sunflower seed cake

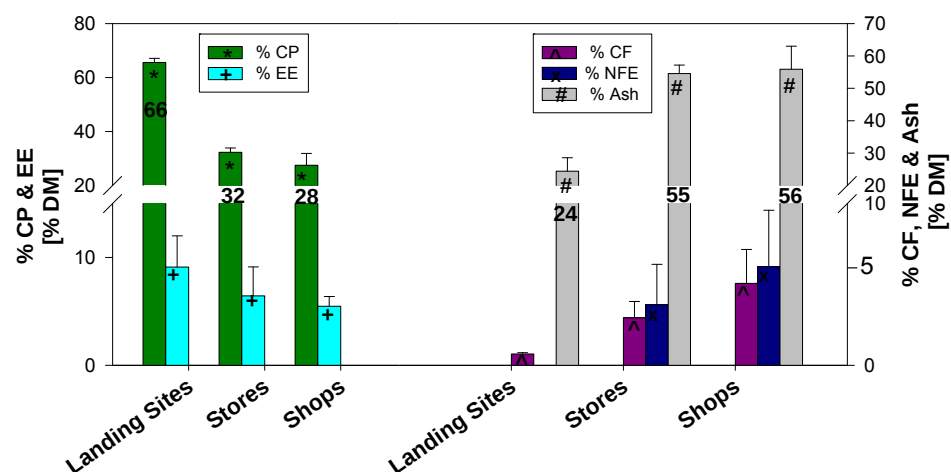


Figure 32: Composition of fish meal along the supply chain



Figure 33: Rosemary Nalwanga at work

Some potential formulations for *O. niloticus* in cages:

Ingredients	Inclusion level (%)	Ingredients	Inclusion level (%)
Omena meal	10.0	Fish meal	10
Cotton seed	0.1	Ground nut cake	16.1
Breweries waste	49.6	Rice bran	26.1
Wheat bran	40.4	Soybean meal	18.3
Filler	0	Maize bran	29.4
Total	100.0	Total	100.0

Ingredients	Inclusion level (%)	Ingredients	Inclusion level (%)
Shrimp meal	10.0	FWS	10.0
Cotton seed	0.0	Cotton seed	12.0
Breweries waste	45.2	Breweries waste	29.4
Wheat bran	42.2	Wheat bran	23.1
Filler	2.6	Maize bran	25.6
Total	100.0	Total	100.0

A number of publications and research papers have been produced from this work package and they include:

Publications (Available in PDF format)

- J.Munguti et. al., 2007 (*Austrian Journal of Agricultural Research*)
- R. Nalwanga et. al., 2009 (*Journal of Livestock Research and Rural development*)
- J.Munguti et. al., 2009 (*Journal of Livestock Research and Rural development*)
- H. Charo-Karisa et. al., 2009 (*Sarnisa compedium*)

Four papers were submitted, 3 are in preparation.

The following thesis have been undertaken:

J. Munguti- Kenya (PhD)

K. Hammerl - Austria (MSc)

R. Nalwanga- Uganda (MSc)

S. Assmann, - Austria (MSc)

B. Heimberger- Austria (MSc)

Ben Obwanga (MSc) Kenya

Kassahun (PhD) Ethiopia Ongoing

Achievements for task 5.4 Formulation evaluation of performance of fish growth (M18 – M30)

Evaluation of diets that are **effective** and **cheap** in the culture of *O. niloticus* by assessing the **effectiveness** of selected **plant materials** as substitutes for **freshwater shrimp meal**, in the conventional Sagana diet was carried out at Sagana Aquaculture Centre by Post and undergraduate students from Moi and Egerton universities supervised by Dr. Liti and Prof. Wathuta.

In Ethiopia: Feed experiment using *O. niloticus* and *T. zilli* were conducted at Sebeta National Fisheries and Aquatic Life Research Center. Results of this feeding experiment showed variations in feeding activities. Generally the growth of fish was poor and this may be due to low water temperature, low feeding rate. However, *T.zilli* was feeding more actively than *O. niloticus*. Some fish mortality was observed during the experiment.

The growth of fish in Yemilo was monitored and the overall growth of the fish was found to be slower than expected this could be attributed to the low water temperature during the rainy period may also contribute for the poor growth performance of the fish. However, there has been big difference in the

growth rate of individual fishes as evidenced in the size range recorded. Fish over 150 gram were (About 50 Kg) selectively harvested and sold at rate of 10 Birr/Kg.

The intensity levels of cage culture may range from extensive to intensive with semi-intensive system occupying an intermediate level. The BOMOSA project adopted the latter mode, where the caged fish are likely to benefit somewhat from the available natural food in the dam in which the cages are installed. To assess the potential ingredients and benefits of natural feed to the caged fish, several experiments were conducted.

Isonitrogenous (250g/kg CP) practical diets were formulated to contain 0%, 25%, 50% or 100% of cassava leaf meal (CLM), pawpaw leaf meal, boiled tea-leaf residues or Hydrolyzed feather meal (HFM). In all the experiments, the Sagana diet, which has been used extensively as a control in research activities in Kenya was used and the performance of fish fed on the other diets were compared to it under intensive and semi-intensive culture conditions. The diets were fed to fish in glass aquaria (representing intensive) and in hapas installed in a pond (representing semi-intensive). All fish were fed 10% of their body weight in three replicates.

Results indicated different degrees of substitution in fish held in aquaria. With the exception of pawpaw leaf meal, which could substitute all the protein in the control diet, none of the other ingredients could replace over 50% of the protein in the control diet. However, all the diets had similar performance in fish held in hapas indicating the significant role played by natural food in the fortification of the nutritional quality of the ingredients. Results from two of the experiments conducted with CLM and HFM are presented below in Fig. 1 and 4 and tables 1 and 2. In both experiments it was possible to replace up to 100% of the animal protein in the diets used to culture *O. niloticus* without adverse effects on fish growth in hapas. However, in the glass aquaria, substitutions beyond 50% of animal protein caused significant ($P < 0.05$) decrease in final average weights.

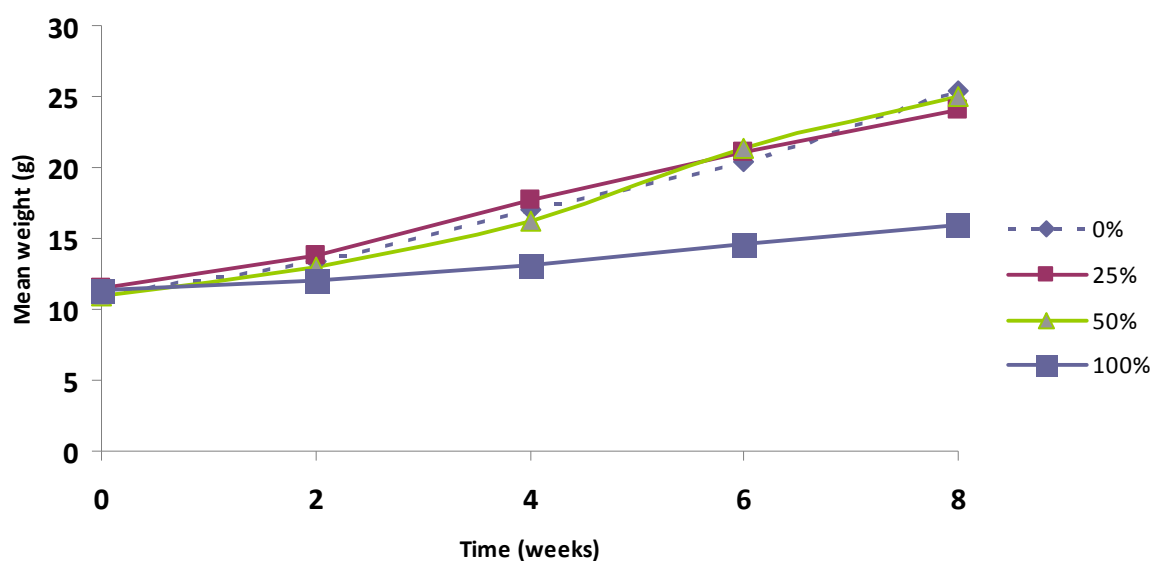


Figure 34: Growth of *O. niloticus* in hapas placed in a fertilized pond

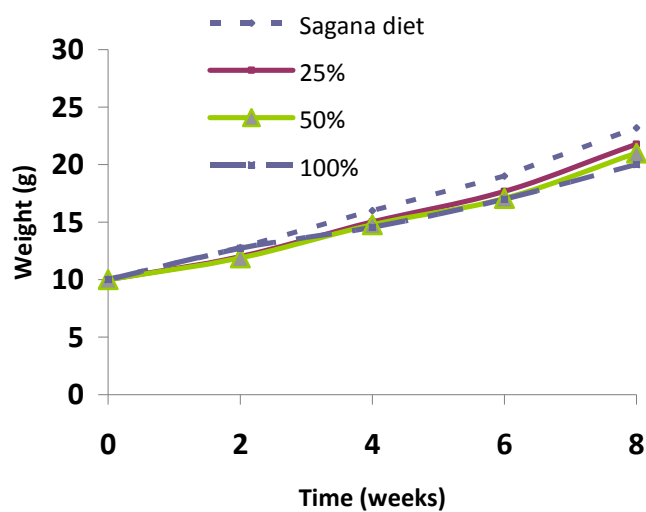


Figure 35: Growth of *O. niloticus* with cassava leaf meal in a semi-intensive pond

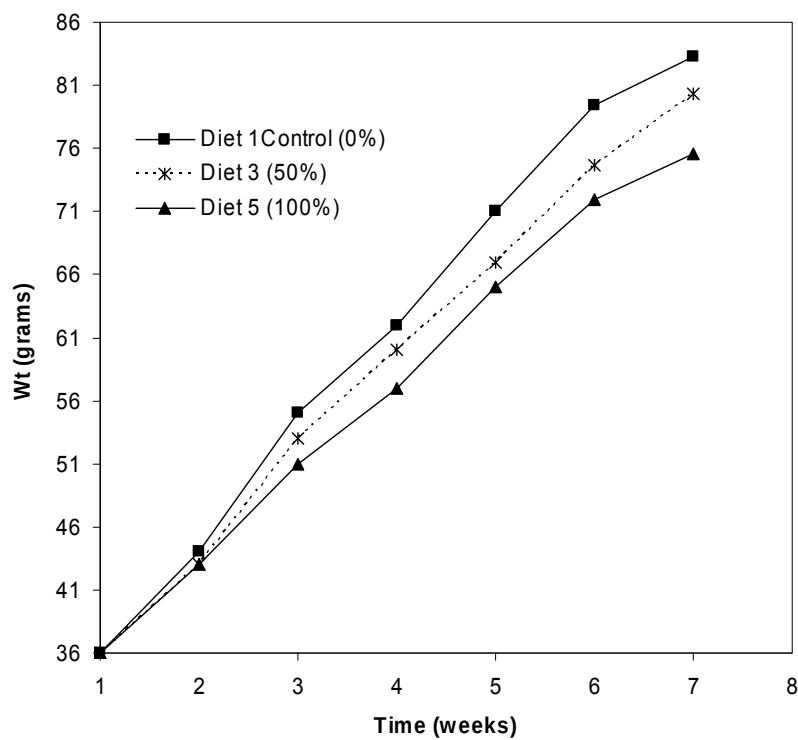


Figure 36: Growth trends curves for *O. niloticus* receiving formulated diets with varying levels of Hydrolyzed Feather meal in aquaria. Showing significant differences in absence of natural food.

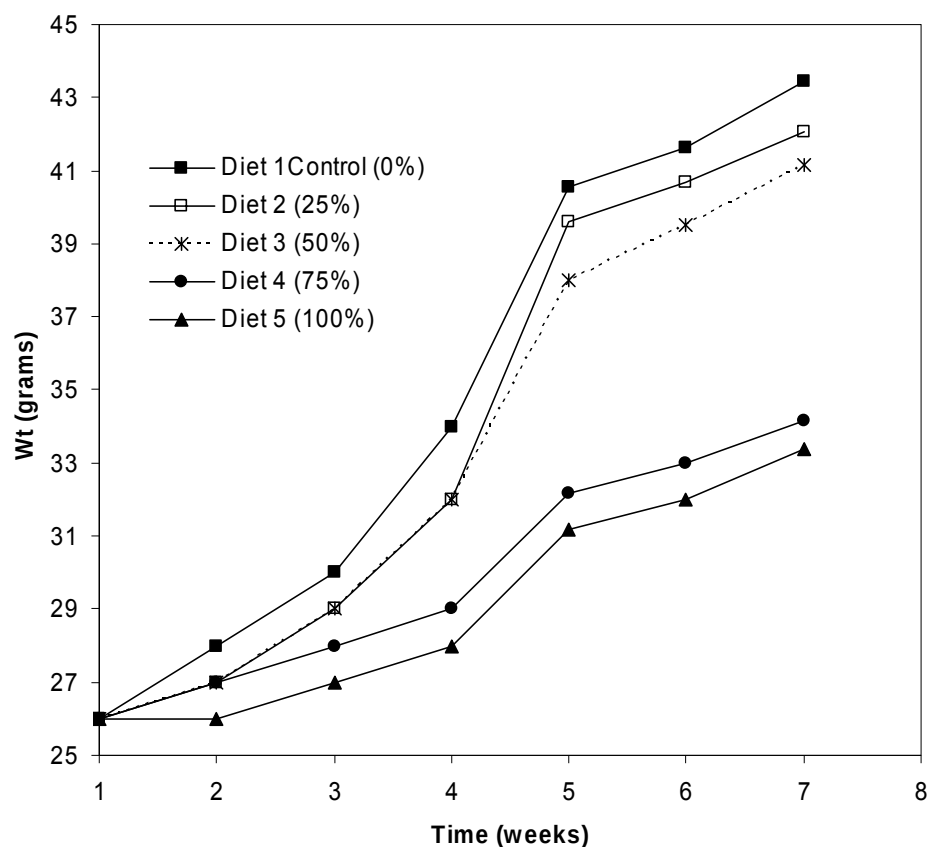


Figure 37: Growth trends curves for *O. niloticus* receiving Fresh water Shrimp in cages

3.5.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 5.1 Survey of available feed ingredients and their costs (M0 – M12)

There were no deviations.

Deviations from task 5.2 Development of feed processing, storage and dispensing devices (M6 – M18)

There were no deviations.

Deviations from task 5.3 Quality and performance of selected feeds (M9 – M24)

There were no deviations.

Deviations from task 5.4 Formulation evaluation of performance of fish growth (M18 – M30)

There were no deviations.

3.5.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 5.01	Report on survey of available by-products as feed ingredients for the three countries	WP 5	2007-09-30	2007-10
D 5.02	Report on blends of formulated diets, suitable processing, storage and dispensing systems	WP 5	2008-03-31	2008-11-13
D 5.03	Optimized prototypes for processing and dispensing the selected feeds	WP 5	2008-12-31	2010-04-01
D 5.04	Report on quality and economic performance of the selected feeds with respect to community level socio-economic targets defined in WP 7	WP 5	2009-03-31	2010-04-01

3.5.6 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 5.1	Suitable feed ingredients are confirmed to be available in sufficient quantities	WP 5	2007-09-30	2007-10	MU
MS 5.2	Processed feeds achieve desired nutritional, storage and dispensing objectives	WP 5	2008-03-31	2008-03-31	MU
MS 5.3	Processed feeds lead to targeted fish production yields	WP 5	2009-03-31	2009-03-31	MU

3.6 WP 6 Technical optimization and monitoring of the BOMOSA plots

To be edited by WP leader according to the requested structure

Responsible: **MU**

Work package duration:

Workpackage start	2007-10-01
Workpackage end	2009-06-30

3.6.1 Workpackage progress overview

Studies were performed to evaluate optimal fish growth performance depending on feeding rate and feeding frequency. Therefore different levels of feeding rate and frequency versus continuously feeding were tested. Additionally water quality was monitored monthly. The economic performance as a key issue for farmers was monitored on the basis of the output of the growth studies. Profitability of the BOMOSA scheme is essential for small-scale farmers to uptake the system. Mono-sex production was tested to enhance the number of male Tilapia, which are in general larger than females. The other problem is that females of *Oreochromis niloticus* are mouthbreeders and don't feed during this time. Trials were done with hormones, which were used for immersion of fry. Fingerling delivery was improved during the whole three years. Different strategies were analysed and tested to reduce the high mortalities due to stress and other factors. A literature survey on post-harvest methods was conducted as well as smoking trials for the conservation of overproduction.

3.6.2 Objectives and starting point of work at beginning of reporting period

The main objectives of this WP will be to optimize the individual BOMOSA plots according to socio-economic targets, evaluate productivity parameters, best management practices and post-harvest preservation methods. Furthermore, the environmental monitoring of the BOMOSA plots will be performed in accordance to the monitoring program designed in WP 4.

The results of the work will go towards producing a BOMOSA manual that will be a key dissemination document to support ongoing operation of the plots upon completion of the INCO project.

Three types of water body will be investigated within the eco-zones including:

Type I: Small public dams/reservoirs where water is not primarily utilized for human consumption

Type II: Temporary rain-fed pools, quarries and ponds in floodplain areas - these will be of two categories; a) those which can be easily seined, especially those without rocks or tree stumps at the bottom e.g. riparian water bodies of lakes. b) those that cannot be easily seined, normally with rocky bottoms or bottom invested with tree stumps, they are usually deep. Different culture techniques (e.g. cage morphologies) will be applied for each type of rain-fed water bodies.

Type III: Existing family (privately owned) water bodies, which are usually man-made, e.g. fish ponds. There are not so many such ponds, so individual families will be encouraged to construct their own ponds where water is available. This may happen within the project, but will more likely be part of the post-project activities planned within the Technology Implementation Plan (WP7).

3.6.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 6.1 Evaluate productivity parameters of the BOMOSA system for the selected test species and plots (M13 – M27)

Monitoring fish growth in cages

Fish growth in cages was monitored on a monthly basis to assess growth potential in different dams. Growth was highest in dams which had higher minimum temperatures and were well mixed. From Figure 38 growth rates can be categorized into two groups, those dams with highest growth rate, those with lower growth rates. However, there is a third category in which fish did not survive to the end of the culture period. This category includes the cases for Ngei and Mailo dams.

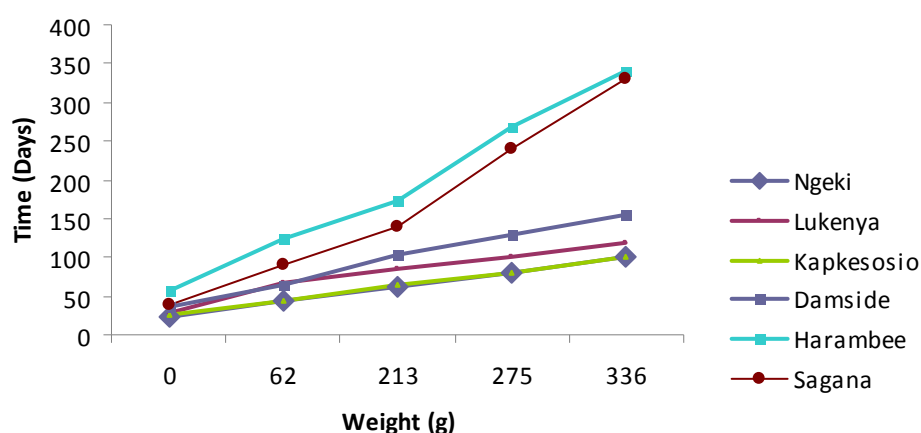


Figure 38: Growth trends of *O. niloticus* in different dams

The performance of fish in terms of growth is not only determined by the quality of feed but also by the amount and frequency at which the feed is offered to the fish. Caged fish have limited access to natural foods and therefore must be provided with adequate food for better survival and growth. Besides feeding rate, feeding frequency plays a significant role in fish performance. In semi-intensive cage culture, which is the target of the BOMOSA cage farming, the aspects of feeding rate and frequency must be evaluated for optimization of growth performance. Consequently, two experiments were set up to investigate the effects of feeding rate and frequency on the growth of *O. niloticus*.

Table 6: Data on feeding rate and growth performance

Parameter	[3%]	[6%]	[10%]	SE
Growth weight (gday ⁻¹)	1.21a	1.56b	1.21a	0.02
Survival (%)	68.7a	69a	72a	1.29
Gross Weight (kg)	9.56a	11.83b	9.96a	0.176
Net weight (kg)	7.57a	9.67b	8.07a	0.177
FCR	3.6a	6.77b	14.23c	0.25
Mean weight (g)	275.9a	343b	275.4a	4.04

Studies were conducted to evaluate the optimum feeding rate at two feeding frequency levels in semi-intensive culture of Nile tilapia (*Oreochromis niloticus*) in cages. Three levels (3, 6, and 10% body weight) of feeding rate and two levels of frequency (twice a day- at 10.00 and 16.00hr) and continuous feeding-between 10.00 and 16.00hr were tested. Water quality was monitored monthly throughout the experimental period. Growth performance (mean weight, net and gross yield) was significantly ($P < 0.05$) influenced by feeding rate but not by feeding frequency ($P > 0.05$). Fish growth was higher at

the 6% feeding rate than at 3 and 10%. Feeding fish at 3% led to growth performance, which was similar to those fed at 10%. Feed Conversion Ratio was significantly different at all the three feeding rates and increased from 3 through 6%. Therefore growth performance of fish fed in semi-intensive cages was optimized at 6% body weight.

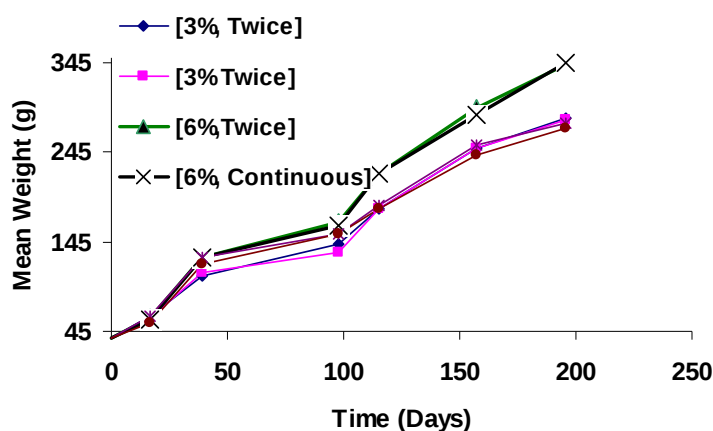


Figure 39: Growth trends curves for different treatment combinations feeding rate and frequency

Economic performance

The aim of most fish farmers is to make profit. Therefore, besides fish growth performance, economic performance is the other focus of many farmers and researchers and more often than not many farmers overlook the former aspect in preference to the economic considerations. The first question from a wide range of farmers; from small to large scale is whether profitability is achievable within the determined culture period. If there is no monetary profit, farmers will be reluctant to take up and adopt the venture however profitable that venture may be in terms of nutrition and other benefits. The profitability of several cage scenarios based on different sizes and numbers of the cages were evaluated during the BOMOSA project. Data from the feeding rate and frequency were used to calculate and construct different profitability scenarios based on cage sizes and numbers at a feeding rate of 6%. The scenarios were based on cages volumes of 1.0, 1.5 and 2 m³ and the numbers ranging between 1 and 10, which are presumed small enough to target small scale fish farmers.

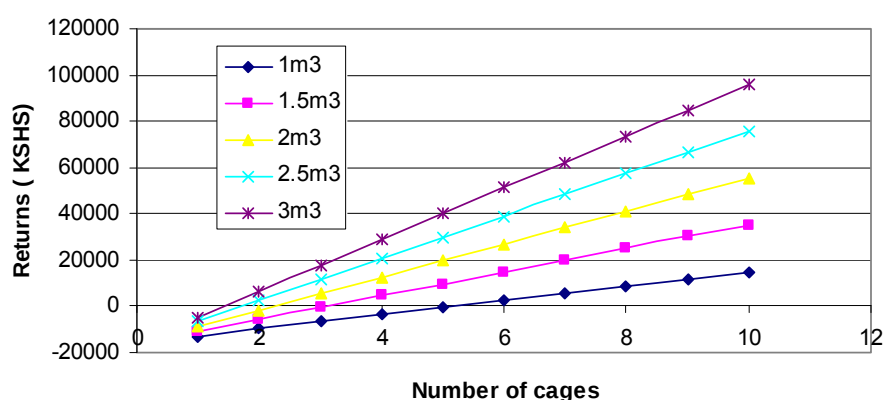


Figure 40: Profitability of different scenarios (cage size and numbers)

The results on economic performance are summarized in Figure 40. Within the range of 1 through 3 m³, no single cage was profitable. For each size, returns increased with the increase in the number of cages. The number of cages required for making positive returns decreased with increase in cage size. Thus the minimum number of cages required to make positive returns were 2, for 2.5 and 3 m³; 3 for 2 m³, 4 for 1.5 m³ and 6 for 1 m³ cage. Returns for 10 cages of sizes 1 through 3 m³ were Kshs 14,955, 35,205, 55,455, 75,705 and 95,955, respectively.

The economic returns structure for the BOMOSAS presented in Figure 40 favour a wide category of farmers from small to medium family. From the monetary point of view based on cage numbers and sizes, it is clear that there are many possibilities farmers could opt to. For example, instead of installing 6 cages of 1 m³, the farmer could use 3 cages of 2 m³ or 2 cages of 3 m³ which have a similar volume of culture. The returns from these two options are more than double that of 6,1 m³ cages. These results are in conformity of the flexibility that had been anticipated in the BOMOSA concept.

Achievements for task 6.2 Evaluation of “best management practices” (M13 – M27)

Mono-sex production

Tilapias display sexual growth dimorphism where in general males grow larger than females. Besides, reproduction in culture facilities is prolific; therefore, a mono-sex population of males is a requirement for better productivity. The most commonly used methods of producing male population are hand sexing and use of hormones. Hormones are usually administered through feeds but this method risks environmental degradation because disposal of the hormone from uneaten food is not well controlled. To enable control the residual hormone, trials on the immersion of fries in hormone solutions were conducted. The trials involved single, double and triple immersions of fry in androgen solution. The best response was obtained with triple immersion which produced 87% males. After the trials, the hormone was destroyed with formalin and the resulting solution disposed.

Fingerling delivery

In order to optimize productivity in BOMOSA plots, fingerling handling techniques are key factor. From our observations, fingerling delivery from the hubs to the culture sites was a serious problem because heavy mortalities were incurred due to stress and other related factors. During the BOMOSA project, strategies for reducing fingerling mortality were initiated. These included transportation during cool Another strategy involved acclimatization to match the conductivity of the recipient water body. After acclimatization to the conductivities, mortality was significantly reduced. Experiments were also conducted to test different strains in terms of stress levels. In this case, three strains were evaluated. The results indicated that the Lake Victoria strain had highest survival while Lake Turkana and Sagana strains had higher mortalities under stressful conditions.

Achievements for task 6.3 Evaluation of post-harvest preservation methods (M19 – M31)

Post-harvest preservation methods were evaluated for storage of harvest over plusses on the one hand. On the other hand post-harvest preservation methods were also considered on their efficacy in inactivating potential zoonotic parasites. A literature survey was conducted, where international literature was studied especially on salting and smoking processes.

At Sagana Aquaculture Center locally fabricated smoking kilns with different capacities were tested. Different types of herbs were tested, as well as hot smoking together with salting. The staff of Sagana also developed a marination and smoking manual.

Achievements for task 6.4 Environmental impact monitoring (M13 – M33)

Veterinary surveys were conducted during the whole duration of the project in all three African partner countries. The outcomes were useful for identifying and listing the possible risks deriving from BOMOSA cage fish farming system in order to give input to the Environmental Impact Monitoring Programme.

The farming conditions of BOMOSA cages (low biomass density, low feeding income, etc.) should not favor the outbreak of diseases and, as a consequence, their transmission to open aquatic environment. Anyway recommendations on prevention and control of the main diseases have been listed and described in detail within reports, deliverables (D4.7) and BOMOSA manual in order to reduce the risk of spreading and impact.

Diel sampling for each BOMOSA plot in Kenya has been carried out three times to assess the short term impact of the thermal regimes on the water quality dynamics in different seasons. Water quality was also analysed on a bimonthly basis to assess the impact of BOMOSA cage fish farming on the reservoir waters.

3.6.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 6.1 Evaluate productivity parameters of the BOMOSA system for the selected test species and plots (M13 – M27)

None

Deviations from task 6.2 Evaluation of “best management practices” (M13 – M27)

None

Deviations from task 6.3 Evaluation of post-harvest preservation methods (M19 – M31)

None

Deviations from task 6.4 Environmental impact monitoring (M13 – M33)

None

3.6.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 6.01	Chapter of "Post-harvest processing and preservation" for the final BOMOSA manual as a contribution to Task 2.3	WP 6	2008-09-30	2008-11-13
D 6.02	Report on minimum BOMOSA production cycles for the various water bodies and eco-zones under economic considerations	WP 6	2008-12-31	2010-04-01
D 6.03	Chapter of "best management practices" for the final BOMOSA manual as a contribution to Task 2.3.	WP 6	2009-03-31	2010-04-01
D 6.04	Manuscripts for peer review and MSc works on environmental impacts of BOMOSA from each African partner country	WP 6	2009-04-30	2010-04-01

3.6.6 List of milestones

Milestone. no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 6.1	Post harvest processing and preservation is a success in terms of customer satisfaction	WP 6	2008-09-30	2008-09-30	MU
MS 6.2	The environmental impact of BOMOSA plots can be described and sustainably managed	WP 6	2009-04-30	2009-04-30	MU

3.7 WP 7 Assess economic viability, social acceptance and ethical issues to develop the BOMOSA socio-economic model

To be edited by WP leader according to the requested structure

Responsible: **EgU**

Work package duration:

Workpackage start	2006-10-01
Workpackage end	2009-06-30

3.7.1 Workpackage progress overview

The work package tasks and deliverables were done and completed on schedule. Having determined that the factors that affect social acceptability and success of the BOMOSA technology ethical and gender concerns, perception of the society on the project, perceived benefits/costs, management issues as well as environmental implications. The task of the workpackage this year was to investigate how these factors could be addressed for successful implementation and up-scaling and where there is lack of clarity, investigate and develop a clear way forward. The workpackage was thus to re-examine all the tasks and draw lessons with the participation of the key stakeholders in the three countries and in all the project sites, towards the development of a Technology Implementation Plan.

3.7.2 Objectives and starting point of work at beginning of reporting period

The objectives of the WP can be summarized as following:

- Determine baseline data of economic viability and social acceptance from existing Kenyan BOMOSA plots to produce the socio-economic targets for the new plots in all three countries (Kenya, Uganda and Ethiopia)
- Perform market analyses at community levels where the new plots will be established
- Assess social acceptability and ethical issues at all new BOMOSA plots
- Perform cost-benefit analyses of the BOMOSA scheme at country level
- Assess IPR aspects and develop a Technology Implementation Plan to promote sustainable post project take up of the BOMOSA scheme

The overall objective of this work package is to assess the economic viability, social acceptance and ethical issues (including ownership, gender and community-related issues) of the BOMOSA scheme in all three countries. These findings will be combined with results of the environmental, productivity and institutional investigations from previous work packages to produce a series of accumulative reports documenting the extent of success and the potential for broad take up of the BOMOSA scheme as a contributor to food security and poverty alleviation in East Africa. The WP will produce a model for sustainable propagation of the BOMOSA scheme within the context of a Technology Implementation Plan. Furthermore, policy recommendations for decision-makers at local, regional and national levels will be produced describing the potential benefits, as well as the necessary obligations associated with widespread implementation the BOMOSA scheme. The reports produced within the WP will be of a scientific nature, which will be transposed into booklets, posters and other informative material within the WP 2 (Participatory approach, capacity building and dissemination), which can then be disseminated to the defined target groups.

3.7.3 Progress towards objectives

Oct'06 - Sep'09

Achievements for task 7.1 Baseline of economic viability and social acceptance of trial BOMOSA plots (M0 – M6)

The baseline established the targets that would govern the directions of the work package are summarized as: the project is expected to make significant contribution to nutrition, food security and sustainable livelihoods of the rural poor.

Baseline conditions assessed at the beginning agreed on the following as the targets of the project.

A. Increase in protein intake

It is expected that with increased accessibility to fish in the area there will be increased protein uptake. The project therefore targets to increase the overall consumption of fish by increasing the households consuming fish as a major source of protein to at least 50 percent in 3 years.

B. Increased off farm incomes

The project is expected to open up income earning opportunities in the site communities. The incomes are expected to increase through:

- Increased direct sales of fish by the farmers/plot owners.
- Income generated through direct and indirect engagement in the fish business.
- Incomes which could be generated by farmers, who will engage in the preparation and sales of cheap, locally made fish feeds.
- Creation of jobs for *jua kali* artisans who are likely to be preparing the cages, repair and maintain the structures.

C. Diversification of resources and integration of fish culture within existing farming systems.

There are wide opportunities for the poor to integrate fish culture within existing farming systems. However, due to the competing uses of resources in the farm it is important to trace the effects of diverting some resources such as Labour, and recyclable farm wastes (e.g. farm yard manure, sweet potato vines, etc). One of the expected targets for the Bomosa dams is to have some of these resources manure diverted into the fish project for use as feeds. This is expected to increase farmers efficiency in the utilization of farm bi-products.

D. Capacity building and skills development and diffusion

Through the project it is expected that there will be skill development, capacity building and empowerment of farmers to help them make informed decision on fish farming. On - the - plot training; the use of community teachers will act as a good way of disseminating information to the farmers living around the plots. The project will also empower the farmers to use locally available feed production materials to boost their farm and off farm incomes through the promotion of low risk, and low external input strategies.

E. Gender diversification in fish farming

Traditionally, development projects in Kenya have seen very active involvement of women while youth and men are not mostly involved, and in most cases they sabotaged the project. However the project will adopt a policy of representation from all groups; Men, women and the youth. This is expected to cultivate cohesion among the village members and ensure project ownership by all. More women and youth expected to take up fish farming and sales, thus influencing the economic base for these two gender groups.

F. Increased supply of fish

A majority of the communities in the project sites attributed their failure to eat fish frequently to irregular supply. It is expected that with the success of the project, there will be more fish both at household level and the market. . This will directly lead to reduction in the prices of fish hence makes them affordable to a larger percentage of the community members.

G. Dam ownership and community organization

Currently, the water bodies have a wide variety of tenure systems, and are mainly used for domestic water supply and farming activities. The control over the water is however not strict. Investment in BOMOSA will strengthen the community ownership as provided for by existing rules and regulations and ordinances on the use of water in the respective sites.

H. Community organization/participation

Currently, approximately 100 households utilize each of the water bodies. It is expected that through diffusion, more households will be able to benefit from the water resource either directly or indirectly through increase community participation in fishing activities.

I. Effect on other sources of proteins

There is the likelihood that there will be more fish available. This will increase diversity in the availability of proteins. As this increases, the prices of other sources of animal and crop proteins (fish substitutes) are likely to go down, as consumers will have a variety of choices to make. More fish was available as each site harvested fish at least twice, with the average production ranging from 127 fish (the poorest site) to over 900 pieces as the best per structure. This, at a current market price (determined per site) gives a value of between Ksh.4,680 to Ksh. 12,000 per harvesting round. Note that though this income is modest, it is a source that was otherwise nonexistent in the community.

On all these targets the projects has realized immense success.

Achievements for task 7.2 Analysis of market conditions for BOMOSA fish products in target countries (M6 – M30)

Fish marketing surveys have revealed that indeed although some communities are generally regarded as non-traditional fish eating communities, fish is being marketed in all the markets in the site communities, with different levels of intensity, variety of fish available and varying status of fish. These findings have been shared at various fora in the country, and it is now a challenge to address the key challenges of marketing namely, Poor infrastructure, lack of proper storage facilities and lack of capital. Various interventions are proposed in the TIP to address this challenge. These include suggestions of linking up with micro credit agencies to support fish farmers in acquisition of requisite infrastructure and capacity building, and cost minimization strategies for both farmers and traders, through collaborative efforts with the Department of Fisheries Kenya. See full marketing Deliverable report.

Achievements for task 7.3 Assess social acceptance and ethical issues at new BOMOSA plots (M13 – M24)

To promote the status of aquaculture and its potential to improve rural food base and especially protein sources of communities in eastern Africa, there is a strong case for introducing aquaculture into areas where it has not previously been practiced. The BOMOSA project sought to do exactly this, by introducing the technology to two non-traditional fish eating communities. The task however involved a lot of field work and trainings provided first by the BOMOSA scientists and then using local skills to extend the technology. At the end of the project, the team can confidently claim to have enhanced the community acceptance in handling fish and also its consumption. At the beginning of the project, the communities in these regions liked to eat fish but feared to handle and process it, especially from the fear of handling small bones. With training and exposure, this fear has now been overcome and more members, especially the women now understand the tilapia and can comfortably handle it as shown in the Figure 41 below.



Figure 41: BOMOSA provided an opportunity to train women and youth on various aspects of fish handling, thus increasing their comfort in this non-traditional role and their interest and participation. (Machakos and Ruthagati)

Achievements for task 7.4 Cost-benefit analysis of the BOMOSA scheme (M18 – M30)

The cost benefit analysis was also carried out for the BOMOSA. It reveals that the investment in BOMOSA as designed during this research phase is not financially viable. This is on account of the huge investment costs and the fact that the construction utilizes non-recyclable and highly sensitive materials. However, there are suggestions that since the investment can break even in the fifth cycle that efforts be made to develop recyclable and sustainable material. This would then make the project both commercially and financially viable. Some of the suggestions have to do with the construction itself. Need to reduce its cost and increase the carrying capacity (subject to the biological characteristics of the water body) through efficient management, Reduce cost of maintenance and also re-use of construction materials. This has to be coupled with a judicious matching of stocking cycles which are specific to each site (water body). BOMOSA is an intensive production system. Where there is good management and where the supply of inputs (especially feeds) are stable, the technology can contribute immensely to enhanced protein production by extending and raising the productivity of existing low-input aquaculture systems. Stability of the BOMOSA technology to guarantee a good supply of tilapia is illustrated by the following pictures of the fish harvests at Ruthagati plot in year two (when the rainfall in the country was optimal) and in year three (when the country was undergoing a severe drought).



Figure 42: Year 2 fish catch



Figure 43: Year 3 fish catch

Cost of the installation and maintenance:



Figure 44: BOMOSA shuttle as constructed after 2 years

All materials used in the construction are currently very fragile and have a short life. The timber, the drums and the twine which holds them together easily rot and rust, making the maintenance of the structure a very costly affair. Work is in progress within the project partners to identify and test more durable and/or recyclable materials to replace the currently used ones.

Achievements for task 7.5 IPR / Technology Implementation Plan (M24 – M33)

One of the most recognized means of enhancing the growth of aquaculture and its contribution to rural livelihoods is to release farmed stocks into open waters to support and enhance fisheries productivity. The BOMOSA technology, though it relies on a constructed site, is amenable to integrative technologies and hence communities appreciate the technology.



Figure 45: BOMOSA Technology is adaptive and can be integrated with other aquaculture technologies to maximise productivity of the water body during periods of low rainfall. (Ruthagati plot, Kenya)

Sustainable, livelihood-focused aquaculture development requires a conducive policy and institutional environment. The policies in the east African countries are relatively young and poorly defined due to the relative novelty of aquaculture and historical reliance on capture fisheries (inland and coastal). From the examination of the legal and regulatory framework in the three countries, it is clear that there is need to understand and widely debate on:

- The policies that affect the environment for aquaculture (e.g. economic, agricultural, environmental and land use policies, investment support, water access, export promotion),
- Their effect on stability and growth prospects of the small scale (youth and group)producers to invest in skill development for aquaculture,

- The responsible institutions / bodies for policy formulation and application and the potential for policy conflicts.
- Community access to adequate information about the potential benefits of small scale aquaculture through an effective and vibrant extension system which is currently very weak and poorly resourced in all the three countries.
- Existence of explicit and documented mechanisms to safeguard resource access for the poor (e.g. public access rights to water body, tenure protection, support to local governance structures) and finally
- The effectiveness and reliability of the marketing channels for aquaculture products.

The attractiveness of aquaculture and by extension the growth and up-scaling of the BOMOSA technology will depend upon many factors, including water body management, community investment abilities and support for the same and the way in which aquaculture interacts with and complements the overall livelihood strategies of different household members and groups.

The TIP can be summarized as below:

Task	Time line	Key actors	Potential challenges
Increase number of water bodies where BOMOSA can be undertaken	Immediately	Ministry of Water and Irrigation, CDF, Ministry of Fisheries Development, Sagana Aquaculture Center, KMFRI	Collaboration may take time, although the Government of Kenya has already set aside funds for construction of dams in every constituency in the country within this financial year.
Enhance Quality of inputs (feed and fingerlings)	Immediately	Ministry of Fisheries Development, Sagana Aquaculture Center, KMFRI	Inadequate budgets and personnel
Enhance community feed production efforts to remove inputs bottlenecks in production cycle	Immediately	Ministry of Fisheries Development, Sagana Aquaculture Center, KMFRI (trainer and documentation)	Inadequate budgets and personnel
Cost efficiency in the production infrastructure	Immediately	Ministry of Fisheries Development, Sagana Aquaculture Center	Inadequate budget support
Conflicting legal and regulatory framework	Immediately	Ministry of Fisheries Development to initiate debate on harmonization of legal frameworks to facilitate aquaculture as an integrative activity	Inadequate budget support.
Community empowerment sensitization and skills development on Aquaculture and fish handling standards	Immediately	Ministry of Fisheries Development is in charge of aquaculture extension in the country	Inadequate budget and reduced integration with other public and private sector extension stakeholders.

The team notes that there is a commitment from all the partners to continue with the tasks as discussed. See detailed TIP attached.

Integrating different water users in the BOMOSA plot will help to reduce the water use and hence ownership conflicts that are bound to arise in a public water body. This would be supported by following the current existing legal and regulatory framework in the three countries that already allow for multiple uses of water bodies that are not the designated drinking water reserves.



Figure 46: Kapkesosio Dam, Bomet Kenya

3.7.4 Deviations from the project workprogramme, and corrective taken/suggested

Oct'06 - Sep'09

Deviations from task 7.1 Baseline of economic viability and social acceptance of trial BOMOSA plots (M0 – M6)

Detailed baseline data were developed and are available for each water body. The water bodies have been geo referenced for easy follow-up, and so have all the farmers interviewed. This will enable impact assessment studies to be undertaken with ease. However, this will only be meaningful if further investment in fish farming continue by the various stakeholders. Originally the team had targeted to have ten (10) plot sites in Kenya but because of the heavy field work involved in identifying, profiling, developing the baseline, undertaking the socio-acceptability survey and then the detailed marketing survey in each site, it became a heavy budgetary constraint and was changed. As a result, only 9 sites were developed in Kenya, although 11 were stocked (two were temporary water bodies where farmers were willing to undertake fish farming and the project assisted them to do so.)

Deviations from task 7.2 Analysis of market conditions for BOMOSA fish products in target countries (M6 – M30)

The original design was that one detailed marketing case study was to be developed for each site. This was practically achieved by undertaking two (2) surveys of time. The first, was a preliminary marketing survey which generated information about the general fish market issues, while the second incorporated the details of the fish marketing and traced our the BOMOSA output as it was harvested and traded. This was done to be able to trace the improvements that can now be attributed to BOMOSA. As a result, the task generated two deliverables D7.2a and D7.2b instead of just one detailed market case study. This can further be enhanced by a later study to incorporate the regional markets into the wider country level fish value chain assessment.

Deviations from task 7.3 Assess soivial acceptance and ethical issues at new BOMOSA plots (M13 – M24)

None.

Deviations from task 7.4 Cost-benefit analysis of the BOMOSA scheme (M18 – M30)

The team, in addition to undertaking a simple Cost Benefit Analysis also undertook a sensitivity analysis to determine which cost items the viability of the BOMOSA is hinged on. We found that the most critical and sensitive costs were the investment costs and the input costs. This means that adequate investment in this sector can make the project economically viable especially for the communities in the marginal and fragile ecosystems.

Deviations from task 7.5 IPR / Technology Implementation Plan (M24 – M33)

This was extended beyond the project to include aspects of up-scaling by the communities themselves. The most critical contribution of this task was to generate a work plan with at least two communities (Ruthagati, Mairo and Lukenya school) on a way forward for up-scaling. These three communities have new committees to manage the next phases of the project and have a clear way forward that includes expansion of the scheme and production of their own feeds using locally available materials. One of the biggest advantages to project is that it has co-incided with a Government project to expand aquaculture productivity in the country and construct multi purpose water harvesting structures (dams and water pans) in every constituency of the country.

This will greatly ease the task of implementing the TIP for BOMOSA.

3.7.5 List of deliverables

Del. no.	Deliverable Name	Workpackage no.	Date due	Actual / Forecast delivery date
D 7.01	Report on baseline data for existing plots and socio-economic targets for the new plots	WP 7	2007-03-31	2007-03
D 7.02	Market reports with case studies for each plot at community level	WP 7	2008-03-31	2008-11-13
D 7.03	Reports on social acceptance and ethical issues with case studies at community level	WP 7	2008-09-30	2008-11-13
D 7.04	Cost-Benefit Analysis of the BOMOSA scheme with case studies at country level	WP 7	2009-03-31	2010-04-01
D 7.05	TIP for BOMOSA within East Africa with policy recommendations	WP 7	2009-06-30	2010-04-01

3.7.6 List of milestones

Milestone no.	Milestone Name	Workpackage no.	Date due	Actual / Forecast delivery date	Lead contractor
MS 7.1	Socio-economic targets are able to be defined for the selected plots / regions	WP 7	2007-03-31	2007-04	EgU
MS 7.2	Market reports confirm sufficient demand for the BOMOSA fish products	WP 7	2008-03-31	2008-09-30	EgU
MS 7.3	BOMOSA is confirmed to be socially acceptable and presents no ethical conflicts	WP 7	2008-09-30	2008-03-31	EgU
MS 7.4	The scaled up BOMOSA scheme shows anticipated potential and is described in the TIP	WP 7	2009-06-30	2009-06-30	EgU

Section 3 - Consortium management

4.1 Consortium management tasks and their achievement

Oct'06 - Sep'09

Achievements for Task 1.1 Contract Management (M0-M36):

During the whole duration of the project there was a change of EC-officers responsible for the BOMOSA project. In total we had 3 scientific officers and 4 financial officers. On behalf of the coordinator it has to be reported, that the changes took place without any troubles and all EC-officers were very cooperative. Within the management team there was a change of project managers. With end of 2007 DI Michael Straif left university and his position was assigned with DI Silke-Silvia Drexler, who took over the whole project with beginning of 2008.

Achievements for Task 1.2 Coordination of scientific and technical activities (M0-M36):

The management of the consortium has been established as planned under WP 1 in the Technical Annex. Prof. Dr. Herwig Waidbacher was the overall project-coordinator and responsible for the implementation of scientific and technical activities. He was assisted by a project manager, whose responsibility was in the area of financial and administrative issues. The inner African coordinator was Dr. David Liti, who was very important for the direct contact between the European and the African partners. Whenever there occurred any troubles he was there to discuss them and to find a solution. Dr. Liti was also important regarding the reporting procedure, as he was pushing the partners to meet the requested deadlines.

Achievements for Task 1.3 Coordination of meetings and workshops (M0-M36):

Over the three years of duration nine consortium meetings/workshops/conferences were organised. In every period three meetings took place. The events were always organised in close collaboration with the hosting partner; in most cases with partner 5 (MOI). Also workshops were held, in conjunction with other meetings, which were mainly organised by the workshop managers with the respective partner country leaders. For each event an agenda was prepared to ensure an effective time management and to tackle the planned activities. Outcomes of the meetings were documented in the minutes, which were circulated among all involved project staff.

Achievements for Task 1.4 Administrative coordination (M0-M36):

The administrative coordination was understood as a very intensive way of support. Without that kind of partner management most of the requirements could be hardly understood by the partners, as this project was for most of them the first EC-financed one. The complicated modalities had to be presented and explained several times during meetings to fresh up the knowledge of all involved partners. Questions rose mostly covered the financial sector and these were directly addressed to the project manager.

Achievements for Task 1.5 Internal and external reporting (M0-M36):

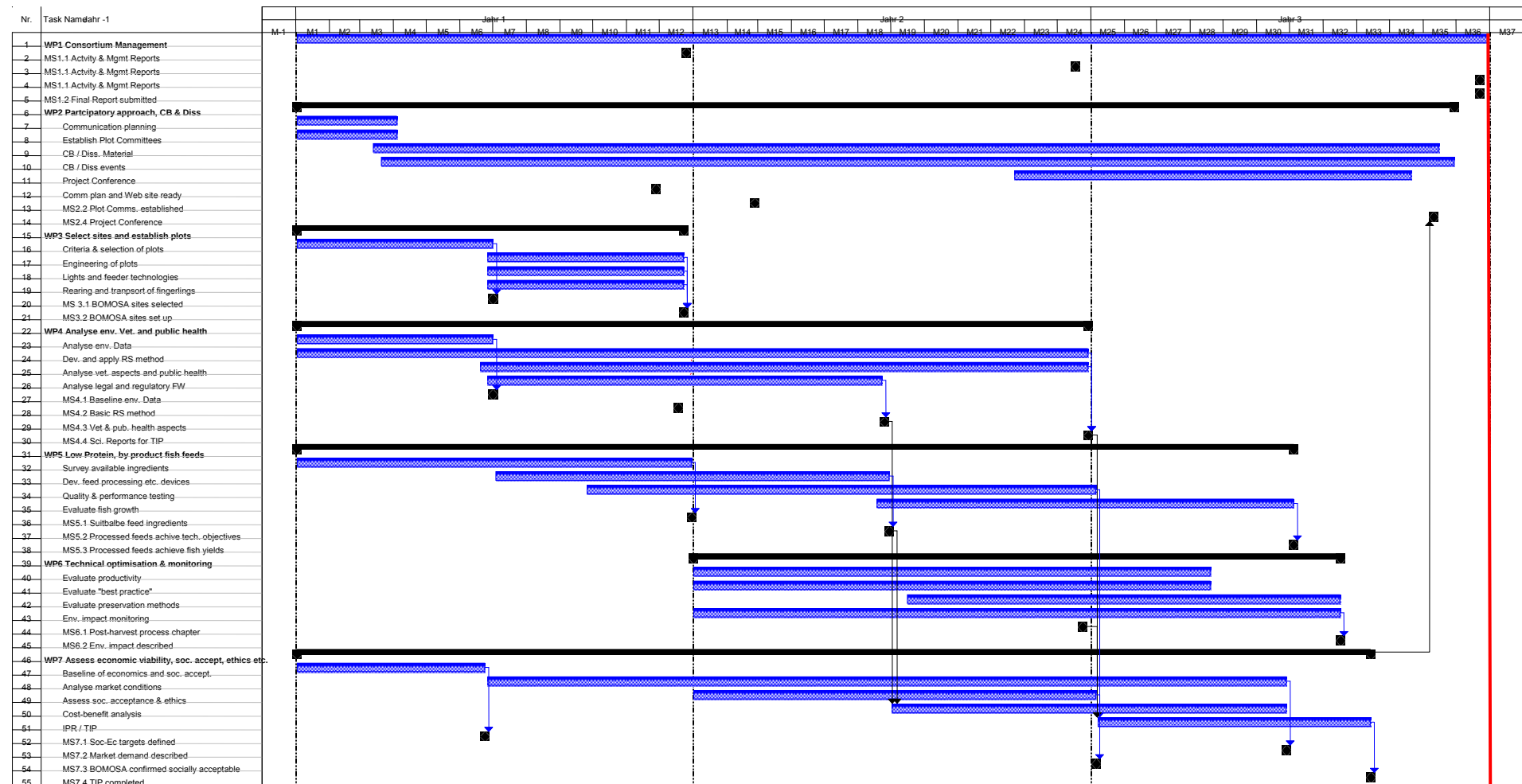
The reporting was based on a quarterly basis. Therefore standard excel and word sheets were prepared by the project manager and delivered among the partners. Financial and scientific activities were recorded per quarter, which facilitated the preparation of periodical reports due to less workload at the end of each period. The internal reports are monitored by the project manager and after revision uploaded to the internal reporting platform.

External reporting is handled by the management team with support from all involved partners. For periodical reports the quarterly reports are updated and fine-tuning is done by BOKU.

4.2 Comments regarding contributions, changes in responsibilities and changes to consortium itself

During the whole duration of the project there was a change in responsibilities concerning the project manager. DI Michael Straif, the project manager during the first year, left University with end of 2007. He was replaced by DI Silke-Silvia Drexler, who was a project assistant in period 1. She was introduced to the partners, instructed on management some months before and took over the whole project with beginning of 2008.

4.3 Project timetable and status



4.4 Comments and information on co-ordination activities in the period

Basically it can be reported that no serious major problems hampered a fruitful and successful working period in the first year of the project. All consortium members behaved in a very constructive way in solving minor problems for the fulfilling of the first year's goals. There is a good spirit in the group detectable at the beginning of the second year, all the members are satisfied with the fruitful cooperation - as they mentioned at the one week annual meeting in October – and it seems that the intensive measuring and analysing working packages of the ongoing period could have been based on a stabile framework of solid performances.

Minor, solvable problems which appeared and the corrective actions undertaken are mentioned in following chapters:

For most of the partners, there are different levels of experiences existing in handling administrative, financial and logistic components of an EC project. Some of the African partners had never participated in such a project and behaved a little bit shy in the beginning in starting handling budgets and employing co-workers. When this became visible to the coordinator and to the project manager the frequency of meetings with the African partners was increased immediately. This increased the level of confidence and nearly all problems could be sorted out by face to face contacts. The frequency of visits of the coordinator/manager with the African partners was even more increased when coordinator and project manager stopped travelling together and started travelling alternately. Almost every month either the coordinator or the manager - sometimes both together - were visible to the partners and participated in specific discussions, detailed planning and administrative supporting. Additionally a higher frequency of meetings between the African partners was stimulated. These measures did not develop a counterproductive dependency between the partners but a high responsibility for a continuous uninterrupted working scheme. The encouraged travel activity of the African partners enabled especially the improvement of the contacts to potential plot communities, the careful selection and recruitment of the final plot community participants and ended up with satisfying arrangements and commitments for both sides. Time investment in handling the socioeconomic aspects is presumably one of the most essential parameter which decides over success or failure of the project. On the other hand, after the first year it becomes obvious that the scheduled budget clearly underestimated the necessary travel costs. But looking to the results, where all the targets of the first year have been reached, we have a strong tendency to follow this successful route of "high frequency meetings" in the remaining two years.

Due to traditional academic structures and complicated administrative regulations, it seems to be not easy for most of the African partners to employ additional personal in the continuous amount calculated in the beginning. Traditionally, participating colleagues from African partners don't like to delegate crucial parts of a working load to other personal because of their strong sense of responsibility to the outcome of results. The present project started with low activities in employing of additional personal, increased these activities when plot planning, -constructing and feeds analyses started and kept the level constant by continuing activities for general analyses plus maintaining of the plots. The present level of additional employed personal should be seen as characteristic for the duration of the project with the ability to produce good results as proved in the first year. With respect to the duties of observing the balance of the budget, neither the coordinator nor the manager put pressure on the African partners to increase the spending for additional personal in the moment, because, as mentioned in the upstanding paragraph, the approved strategy of "high frequency meetings" could not be elongated with a higher quantity of travelling employees of the African partners within the East African region.

In the category of administrative problems we had some troubles with the new customs regulations in Kenya. Equipment for plot installations (mainly net material and mechanical feeding machines) had to be sent from Europe to Eastern Africa. While partners in Uganda and Ethiopia were able to request special permits to get there equipment without hindrance through custom regulations, Kenyan regulations constrained us in planed activities for more than four month and needed exceptional efforts from the project manager (M. Straif) and the African leader (D. Liti) in organizing international material testing protocols, or in trying to reduce unexpected high custom fees. After all we were able to catch up the time losses through perfect construction management of the nine Kenyan plots (responsible R. Mbaluka). For future activities in international material shifting we have to calculate extremely long administrative procedures with this particular country.

For the reporting period of the second year it generally can be noted that no major serious problems with dramatic impact on the BOMOSA project can be reported. All consortium members performed in

a serious constructive way in solving minor problems for the fulfilling of the project goals. There is still a good spirit in the group detectable at the beginning of the third year. The positive atmosphere became visible at the one week annual meeting in October in Kenya when the numerous results from the members of the different work-packages were presented and the extraordinary strong response of potential future stakeholders and high ranked political decision-makers was proudly discussed. It seems that the workload of the ongoing period is based on a stable framework of solid performance.

Solvable problems which appeared – as well as the corrective actions undertaken - are mentioned in following chapters:

In January/February 2008 political riots and clashes appeared in Kenya after the election. Major targeted areas were the central province and the lake area in the northwest. The project coordinator immediately travelled to Kenya to get personally informed about the problems expected for the ongoing of the project. Supporting the plots with fish-feed as well as technical equipment and sufficient replacement of fingerlings to compensate some unexpected fish-mortality in the cages turned out to be the major problems. The range of travelling was clearly restricted for all of our Kenyan partners. With high personal effort of our partners, the organisation of a functioning courier-service with reliable persons and friends could be established to send goods and information to the targeted plots. With outstanding high commitment for their plots the relevant plot-managers and communities guarded the cage assemblages. Only a single cage was lost in the whole time of violence. The extra-services for the ongoing needs and replacements in those turbulent times resulted in explainable higher costs for travel activities.

Due to unexpected high siltation in the water-reservoir of Kasolwe (Uganda) the Ugandan partner in accordance with the project management and the responsible plot committee decided to move the whole plot construction with the net-cages and feeding logistic to the reservoir of the Busoga High School near Kamuli district town. A new plot-committee - with teachers and students involved – was organised and well established. The enthusiasm for the new BOMOSA-plot was high from the very beginning and the multiplying effect for spreading the news through students to their home-areas is welcomed by the partners and management. The Ugandan minister of agriculture already visited the location and was very impressed from the commitment and the acceptance of the system. The “old plot” at Kasolwe will be re-established after de-siltation works are finished in the original reservoir – a promise has been given to the local plot-committee. Additional costs for plot movement works, increased travel-effort and limnological sampling as well as supervision and assistance for Busoga High School can clearly be explained as necessity for the posi

A similar situation as in Uganda appeared in Ethiopia. The plot of Alage has been moved to a new area closer to be supported by the hub of Sebeta. The reasons for the relocation was the competition for water in the original reservoir at Alage, demands for irrigation have been matching the demands for cage fish production and resulted in reduced water levels in the reservoir. The Ethiopian Partner together with the responsible plot-community and the project management decided to shift the whole assemblage to Wonji – a reservoir more predictable in water availability and located close to the bank of river Awash in the area of Nazareth. The responsible community – mainly sugarcane farmers – welcomed the project and started immediately to cooperate by forming a plot-committee. Additional costs for the Ethiopian partner were incurred in form of material movements, temporary higher travel- and transportation costs as well as additional spending for supervising the new community group. These unexpected costs are reasonable for the successful progress of the project in Ethiopia.

During the maintenance of the plots with fish-fingerlings it appeared that serious unexpected mortalities happened after acclimatisation of the fish in the new cage-environments. In Kenya majority fish from our hub at Sagana (Sagana-lake-Victoria-Nile-Tilapia-strain) have been distributed to most of the Kenyan plots. Several trials with different modes of transportation techniques were performed with unsatisfying results. Finally the distribution of Lake Victoria strain fingerlings from Sangoro research-fish-farm showed the most positive performance. The Kenyan partners and the management decided to continue stocking with the Sangoro strain. This important finding made its own serious contribution to increased travel costs for the Kenyan partners.

Due to the enormous response of high ranked political decision makers and stakeholders – one president, three ministers, delegations of members of parliament and local administrators – all partners came under pressure to support the requirements for demonstration and dissemination of the BOMOSA fish-farming system. Generally it can be mentioned that the outstanding high effort for such dissemination events resulted in increased travel costs. Nevertheless the achieved results of the ongoing project justify the spending.

In the third year of the BOMOSA project it can be noted again, that no dramatic, serious problems with major impact on the finalising of the project can be reported. The consortium members performed in

the expected serious way, at all conferences and meetings delegates of the member organisations appeared, presented their contributions to the respective work-packages and took part in any discussion. Strong interest could be detected from side of the politicians in all three Eastern African countries, as well as from decision makers and fish producing farmers. An unexpected good spirit was introduced through the two school plot partners, where dissemination happened extremely effectively. In the final conference participants appeared from the regional FAO office in Addis Ababa (Ethiopia) plus delegates from West Africa with high specific knowledge in tilapia farming. Because of the strong feedback from communities, decision makers and policy the service effort of the partners as well as of the project management was higher than planned. Minor deviations from the cost budget can mainly be explained by servicing the unexpected intensive feedback mentioned above.

Majorly deviations in position of travel and subsistence – which have been criticized in the former years – have been controlled as good as possible by the central management team and from our side it can be guaranteed, that all additional travelling was really necessary in any details.

Small deviations in expenses also appeared for maintaining the existing plots in the countries. Kenya had a small security problem in Harambee (Lake area plot), where two cages have been stolen during minor ethnic conflicts, Sagana (central region; hub and demonstration plot) lost a shuttle float and Machakos (arid area) closed the plot in Ngei due to limnological water conditions and the cages were distributed to the prospering production areas.

In Uganda they moved onwards with BOMOSA equipment from the established Busoga High School plot to a nearby school pond area in Kamuli district where minor additional costs have been spent with an excellent distribution factor.

In Ethiopia the technology has been proved for extension in the shore area of existing Rift Valley lakes. Lake Kiroftu was chosen and a completely new plot was established, which is serviced from the Sebeta group. In Ethiopia equipment for food analysis had to be replaced and caused additional minor costs.

In the Kenyan hub Sagana post-harvest processing of fish has been trained to people in offensive manner connected to aquaculture training courses. A modified technology of fish smoking was developed in a self-constructed smoking kiln with high acceptance from communities and farmers, which led again to unexpected smaller additional costs.

The introduction of new fish feeds guided the groups in the direction of breweries waste, which showed a reasonable good profile in nutrients and acceptance by the fish, but had to be managed in bigger quantities with higher drying effort and storing capacities plus in some areas (Kenya, Uganda) with unexpected spending.

The started introduction of more robust strains for fingerling propagation in the hubs of the three different countries went on. Therefore new genetic material was collected in remote area, which led to additional travel costs. The observed stress conditions during transport rose as serious aspect to be solved when enforcing the hub-plot fish feeding logistics. Additional experiments in the stress evaluation went on in Sagana (Kenya) as well as in Vienna (Austria). Tendencies of handling such stress situations could be proved with comparably low cost methods.

Due to the enormous response and expectations from side of the decision makers and stakeholders all partners behaved very supportive with the investment of minor additional costs in travelling and consumables. Nevertheless the achieved results of period three and their implementation as well as the distribution and applied acceptance justify the spending, which has been proved from the management in all details.

Section 4 – Other issues

5.1 Gender issues

The number of women integrated in the BOMOSA project is relatively low. The low female participation is not remarkable as the field of work is most technically based. Nevertheless women are also positioned in leading roles, like Ms. Maria-Letizia Fioravanti from partner 4 (UNIBO) who is responsible for veterinary aspects (WP 4). There is also Ms. Njeri Muhia from EGU (partner 8); she is the work package leader for WP 7 and within the WP the specialist on socio-economic issues. To the project team also belong PhD students from both the African and European partners.

Team leader:

- Maria-Letizia Fioravanti (UNIBO); Italy
- Njeri Muhia (EGU); Kenya

Team members:

- Silke-Silvia Drexler (BOKU); Austria
- Nadja Straubinger (OEAW); Austria
- Petra Hesslerova (ENKI); Czech Republic
- Daniela Florio (UNIBO); Italy
- Monica Rotich (MOI); Kenya
- Hellen Warugu (MOI); Kenya
- Geraldine Matolla (MOI); Kenya
- Mary Kaggwa (MOI); Uganda
- Prisca Loisi (MOI); Kenya
- Nancy Ngare (MOI); Kenya
- Eunice Ngari (EGU); Kenya

MSc students:

- Erika Ramsauer (BOKU); Austria
- Konnie Hammerl (BOKU); Austria
- Iris Kagerer (BOKU); Austria
- Ramona Gabler (BOKU); Austria
- Carina Gollubics (BOKU); Austria
- Beatrix Gasienica-Wawrytko (BOKU); Austria
- Birgit Heimberger (BOKU); Austria
- Sabine Assmann (BOKU); Austria
- Christina Stöger (BOKU); Austria
- Cornelia Gutmann (BOKU); Austria

5.2 Ethical issues

There are no ethical issues associated with the BOMOSA project.

Annex – Plan for using and disseminating the knowledge

Section 1 – Exploitable knowledge and its Use

Overview table

Exploitable Knowledge (description)	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use	Patents or other IPR protection	Owner & Other Partner(s) involved
BOMOSA technology	BOMOSA modified plot design / construction	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
BOMOSA technology	Improved BOMOSA fish feeds, formulated from agricultural by-products	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
BOMOSA technology	Fish grading machines	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
BOMOSA technology	Fish feeders	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
BOMOSA technology	Smoking kilns	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
Remote Sensing Tool to identify small water bodies	Remote Sensing Tool	Aquaculture, irrigation / agriculture, life stock management, water supply	Already free public usable	n.a.	BOMOSA consortium
Occurrence of toxic cyanobacteria in small water-bodies	Risk assessment of toxic cyanobacteria blooms	Aquaculture, life stock management, water supply	Already free public usable	n.a.	BOMOSA consortium
Occurrence of parasites in Nile Tilapia in East-African countries	Risk assessment of parasites	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
Behavioural patterns	Feeding behaviour on developed feed stuff	Aquaculture	Already free public usable	n.a.	BOMOSA consortium
Limnological suitability of water bodies	Risk assessment of small-scale cage culture	Aquaculture; limnology		n.a.	BOMOSA consortium
Socio-economic survey of targeted communities	Questionnaires	Socio-economic		n.a.	BOMOSA consortium

Section 2 – Dissemination of knowledge

Capacity building and dissemination events

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
September 2007	Poster on "fish parasites of wild and cultured fish from Kenya and Uganda"	Scientific community	Europe	> 200	UNIBO	Italy	
October 2007	Training activities on laboratory techniques, fish parasitology and fish pathology	Scientists, Master students, Technicians	Et	10	Unibo, EIAR	It	Protocols, Articles, Powerpoint files
October 2007	Training activities: Bacteriological training at Sagana Fish Farm & Egerton University, (bacteriology sampling technique, inoculation, preparation of smears, staining, identification)	Scientists, Master students, Technicians	Ke	10	Unibo, EGU, MU, Sagana	It	Protocols, Articles, Powerpoint files
October 2007	Training seminars on fish disease, pathology, ecological/environmental aspects of fish parasites	Scientists, Master students, Technicians	Ug	20	Unibo, DFRU	It	Protocols, Articles, Powerpoint files
October 2007	Presentation of BOMOSA to Makerere University staff members	Heads of the Faculty of Veterinary Medicine of Makerere University	Ug	6	Unibo	It	Powerpoint files
December 2007	Site demonstrations and discussions were organized at plot sites where transported fingerlings were acclimatised and stocked in cages at Ngeki and Lukenya sites	plot communities	Kenya	30	DFK, MU	Ke, At	Pics,
January 2008	BOMOSA posters, Photos exhibition SNNPRS, Bureau of Agriculture, Awasa..	Exhibition visitors	Ethiopia	30000	EIAR	Et	photos
February 2008	Workshop on wetlands	university students, lectures	Czech Republic	40	ENKI	CZ	Book of abstracts, ppt
February 2008	State visit in Ethiopia (Sebeta) of the Austrian president, his wife and delegation	delegates of policy, economy and science; scientists; reporter	Ethiopia	100	EIAR, BOKU	Et, At	booklet, pics, newspaper reports
February 2008	Site demonstrations and discussions were organized at plot sites where transported fingerlings were acclimatised and stocked in cages at Ruthagati site	plot communities	Kenya	15	DFK, MU	Ke	pics and reports
March 2008	Oral presentation "Phytoplanktongemeinschaften und Microcystinproduktion in kenianischen Fischteichen".	Scientists	Germany, Austria	80	OEAU	At	Powerpoint

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
March 2008	One week RS course - part 2 , Debre Zeyt, Ethiopia	BOMOSA partners	Eastern Africa	14	EIAR, Egerton University, KMFRI, DFRU	CZ	Landsat data, manual, DVD, ppt
March 2008	Site demonstrations and discussions was done at Sagana site	Director of Fisheries Kenya	Kenya	5	DFK	Ke	pics and reports
March 2008	BOMOSA posters, Photos and cage proto type exhibition on 40th anniversary of EIAR	Exhibition visitors	Ethiopia	20000	EIAR	Et	Photos
April 2008	Workshop on cooperation/research activities of the Faculty of Veterinary Medicine of Bologna, Italy	Scientists, Master students, Technicians , Politicians, Industry	It	180	UNIBO	It	Powerpoint files
April 2008	BOMOSA PROJECT meeting: Trip to Addis Ababa-Ethiopia	BOMOSA partners, community representatives and EC representative	partner countries	20	all partners	Ethiopia	Pics
April 2008	Capacity building on aquaculture methods & BOMOSA	Students from Austria and Kenya Universities	Eastern Africa and Austria	10	DFK, EGU, MU, KMFRI, OEAW	Ke	pics and reports
May 2008	Poster presentation "Toxin production by cyanobacteria in fishponds in Kenya"	Scientists	Austria, Germany, Kenya, Tanzania, Ethiopia, Burkina Faso	70	OEAW	At	Powerpoint
May 2008	BOMOSA posters, Photos and cage proto type exhibition on 100th anniversary of MoARD.	Exhibition visitors	Ethiopia	50000	EIAR	Et	Photos
May 2008	Broadcast presentation of BOMOSA - "News in science"	broadcast listeners	Czech Republic	100000	ENKI	CZ	record
June 2008	BOMOSA stand & poster presentation at international exhibition "Bridging Research, Technology and Development: Initiating an interactive stakeholders' partnership for sustainable water resource development", Kisumu, Kenya.	Scientists, NGO's, policy-maker, private sector	Eastern Africa	140	EGU, MU, DFK, KMFRI, EIAR, OEAW	Ke, At	Pics, Poster, Article
June 2008	DFRU BOMSA workshop	School teachers, students, and community of Busoga High School ,District Fisheries Staff	Uganda	94	DFRU	Ug	Photos, workshop report

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
June 2008	XXV Conference of the Italian Society of Parasitology (SOIPA)	Scientists, students	Italy	150	UNIBO, EGU, MU, DFRU, EIAR, Sagana	I	Scientific abstract in the Proceedings of the Conference
June 2008	Bomosa hosting fish farmers from millenium Village in yala at Harambee bomosa site	Current and potential fish farmers	Kenya	65	KMFRI	Ke, At	Pics
June 2008	BOMOSA Poster in East African Water Association (EAWA) exhibition, KISUMU Tittle " Enterprise diversification and improved Preotein Intake for Small Scale Farmers in Kenya, A case of BOMOSA cage fish farming in temporary water bodies	Scientists, NGO's, policy-maker, private sector	Kenya , Uganda and Tanzania	140-160	EGU	Ke	Poster, Article
July 2008	Minister of Fisheries 1 day capacity building/information session on BOMOSA site at Harambee site.	Scientists, NGO's, policy-maker, community,	Kenya	150	EGU, DFK, KMFRI	Ke, At	Pics
July 2008	Training activities on fish pathology, bacteriology and management of factors influencing the outbreak of fish diseases	Scientists, Master students	Ke	10	UNIBO, EGU, MU, DFK	It	Protocols, Articles, Powerpoint files
July 2008	Hosting the parliamentary Committee on Agriculture, Land and the Environment joined by KMFRI Scientists, other Government Officers and Community Leaders at BOMOSA Harambee Site.	Scientists, NGO's, policy-maker, community,	Kenya	42	EGU, OEAW, MU, DFK, KMFRI	Ke, At	Pics & ppt
August 2008	KMFRI stand at Public Service Week (PSW) Kisumu. Bomosa cages, feed and feeders were demonstrated (KMFRI won the best award)	Scientists, NGO's, policy-maker, community memebrs,	Kenya	500-600	KMFRI	Ke, At	Pics
August 2008	BOMOSA harambee site hosting the Minister of fisheries, Permanent secretary, provincial commissioner, other government officials & communities	Scientists, NGO's, policy-maker, community,	Kenya	160 -200	KMFRI, DFK,	Ke, At	Pics & ppt
August 2008	Focus group discussions in Ngeki, Lukenya, Ruthagati and Mailo	Commuity members	Kenya	120	EGU	Ke	Reports
August 2008	Meeting of Prof. Waidbacher with Ms. Francesca Manta from "Growth Africa Consulting" discussing BOMOSA issues		Kenya		BOKU	At	
August 2008	KMFRI stand at Agricultural show society of Kenya (ASK) Kisumu. Bomosa cages, feed and feeders were demonstrated	Scientists, NGO's, policy-maker, community members,	Kenya	280-340	KMFRI	Ke, At	Pics

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
September 2008	3 days capacity building course on aquaculture for international MSc-student group to BOMOSA sites in Machakos (Int. Training Course on Tropical Limnology)	Young scientists from Eastern Africa	Eastern Africa	18	EGU, OEAW, MU, DFK, KMFRI	At, Ke	Pics, ppt, data
September 2008	Periodical Meeting at Environment Agency, Vienna	Scientist, desk officers	At	15	Subcontractor of UNIBO	At	Powerpoint files
September 2008	RS lectures - The Czech Agriculture University Prague	students	Czech Republic	18	ENKI	CZ	ppt, Landsat data
September 2008	Term course Technical University Turku (water quality management)	students ERASMUS	Finnland, NL, Spain, Belgium, Lithuania, etc.	40	ENKI	CZ	text handouts
September 2008	Ugandan Minister of Internal affairs Visit at Sagana BOMOSA site.	policy-maker, community	Kenya & Uganda	5	DFK	Ke, At	Pics, ppt
September 2008	Gutting of Fish and post harvesting exercise at Lukenya and Ruthagati BOMOSA Sites.	Community members	Kenya	150	EGU, DFK	Ke, At	Pics
September 2008	Broadcast presentation of BOMOSA - "News in science"	broadcast listeners	Czech Republic	10 ⁵	ENKI	CZ	record
September 2008	KMFRI stand at Nyando district food day Bomosa cage culture technology was disseminated , Bomosa feeds and feeders were demonstrated	NGO's, community members,	Kenya	120-130	KMFRI	Ke, At	Pics
October 2008	Poster presentation at Tropentag 2008 Conference, Competition for Resources in a Changing World New Drive for Rural Development, October 7 - 9, 2008, Hohenheim, Germany	Scientists, Universities, NGO's, policy-maker, private sector	World wide	Over 700 people	DFRU		
January, June & July, 2009	Training on cage & pier making, fingerling transportation, pond management and product marketing	farmers, extension agents and experts	Ethiopia	300	EIAR		
February, 2009	Presentations of BOMOSA cage culture technology at "Annual Meeting of Ethiopian Association for Fisheries and Aquatic Sciences"	Scientists, Universities, NGO's, policy-maker, private sector	Ethiopia	115	EIAR		
February, April, July 2009	Demonstrations and presentations on BOMOSA technology at Sebeta Center	University college, & high school students, lecturers, NGOs, extension agents	Ethiopia	2000	EIAR		

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
May, 2009	Presentations of BOMOSA cage culture technology at "International COFA Conference", Ambo, Ethiopia	Scientists, Universities, NGO's, policy-maker (state president and Ministers), private sector	Ethiopia	250	EIAR		
June & August, 2009	TV & radio broadcastings about BOMOSA cage farming	all nation and nationalities	Ethiopia	> 4 Mio	EIAR		
July 2009	KMFRI Bomosa stand at Kisumu Agricultural show	policy-maker, community	Kenya, Uganda, Tanzania	>2000	KMFRI		
September 2009	Final BOMOSA Conference, 2-4 September, Machakos, Kenya	Scientists, government al institutions, development agencies, NGO's, policy-maker, private sector, BOMOSA plot owners	Eastern Africa, Central Africa, Ethiopia, Europe	100	MOI, BOKU, OEAW		
October 2008 - June 2009	Lectures at Czech University of Life Sciences Prague (P. Hesslerová)	Students	Czech Rep	60	ENKI		
April 22 – April 25, 2009	7th International Workshop on Nutrient Cycling and Retention in Natural and Constructed Wetlands in Třeboň, Czech Republic, (J. Pokorný, P. Hesslerová)	Students	EU, USA	50	ENKI		
27 July – 7 August 2009	IPGL – International Training Course of Limnology in Třeboň (Czech Academy of Sciences – Institute of Botany) – Mau forest study used for education purposes	Students	Africa, South America, Nepal, Czech Rep	20	ENKI		
19 March 2009	Seminary at Faculty of Science, University of South Bohemia in České Budějovice	Students	Czech Rep	50	ENKI		
February - June 2009	Faculty of Science, Charles University in Prague, lectures on Fingerponds and BOMOSA in Eastern Africa	students + public	Czech Rep	50	ENKI		
April to July, 2009	Czech TV broadcast "Nature, Environment and the Earth protection"	General public	Czech Rep	1.2 Million	ENKI		
October 08 - September 09	Czech radio broadcast "Natura, Odysea, Dusek"	General public	Czech Rep	300000	ENKI		
15./16. September 09	Call for Africa FFG-Networking Day	Scientists	Africa, Europe	200	BOKU		

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
September 2009	Final BOMOSA Conference "Integrating BOMOSA cage fish farming system in reservoirs, ponds and temporary water bodies in Eastern Africa	Scientists, governmental institutions, development agencies, NGO's, policy-maker, private sector, BOMOSA plot owners	World wide	800	BOKU, OEAW, MOI		
December 2008	Lectures at BOKU University (Bodenkulturwissenschaften für Entwicklungsländer)	Students	Austria	50	BOKU		
14. October 2009	Inauguration of the Centre for Development Research	Scientists, Students, decision makers	Austria, developing countries	250	BOKU		
February 2009	Visiting Ethiopian Universities for future-cooperation with Austrian Universities	Scientists, decision makers	Austria, Ethiopia	40	BOKU; EIAR		
December 2009	BOMOSA posters, photos and cage proto type exhibition at "Ethiopian Annual Nation and Nationalities Day"	Exhibition visitors	Ethiopia	45000	EIAR		

Capacity building and dissemination material

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
November 2006	Launching of internal web-based platform for project consortium management and documentation (https://bomosa.bal-pm.eu).	Project consortium	Austria, Czech Republic, Ethiopia, Italy, Kenya, Uganda	50	BOKU	Austria	
February 2007	National TV - five minutes broadcast on BOMOSA approach	General public	Ethiopia	> 1 Million	EIAR	Ethiopia	
March 2007	Article in Moi University Magazine (Chepkoilel Monthly)	Students, scientists & teacher	Kenya	> 1,000	MOI	Kenya	
March 2007	Project web-site (www.BOMOSA.org)	Public, experts and scientists	Global	> 5,000	OEAW	Austria	
March 2007	Field and lab protocols for measuring physico-chemical parameters, phytoplankton, zooplankton, fish-parasites.	Project partners	Eastern Africa and Europe	> 50	OEAW, UNIBO	Austria, Italy	
May 2007	Sign posts at main roads nearby BOMOSA project sites	General public and local communities	Kenya, Ethiopia, Uganda	> 5,000	MOI, DFK, DFRU, EIAR	Ke, Ug, Et	

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
May 2007	4-pages BOMOSA Flyer (Introduction to the BOMOSA aquaculture system).	Public, experts and scientists	Eastern Africa	> 500	DFK, MOI	Kenya	
May 2007	Establishment of BOMOSA corner in shop of Sagana Fish Farm	Public, professionals & students	Kenya	> 500	DFK	Kenya	
June 2007	BOMOSA poster positioned at display room of Sebeta Fish Research Center (Ethiopia)	Public, professionals & students	Ethiopia	> 300	EIAR	Ethiopia	
August 2007	BOMOSA song downloadable at BOMOSA website and played in Kenyan radio	General public	Kenya	> 100,000	MOI, BOKU	Kenya, Austria	
September 2007	Scientific article "Fish Health", Parassitologia, Volume 42, Suppl. 2, 2007	Scientific community	Global	> 500	UNIBO	Italy	
September 2007	BOMOSA ball-pens, caps, t-shirts and shirts as giveaways and for sale at appropriate shops/display-rooms	General public	Eastern Africa	> 500	BOKU	Austria	
September 2007	BOMOSA article in EAWA-Newsletter (Newsletter of Eastern Africa Water Association)	Professionals, scientists, manager	Eastern Africa	> 300	OEAW	Austria	
October 2007	World Food Day exhibition at Kalangala	General public, Government officials, Country diplomats	Uganda	>10000	DFRU	Ug	Poster, photos, BOMOSA brochures
October 2007	Protocols for necropsy, parasitological and bacteriological examination of fish and powerpoint files - Scientific papers and copies of chapters from manual and books	Scientists, Master students, Technicians	Kenya, Uganda, Ethiopia	20	UNIBO, EGU, MU, DFRU, EIAR, Sagana	I	Protocols & powerpoint presentation
October 2007	Fabricating 10 Fish grading machines	Scientists, General public (fish farmers), private sector	Eastern Africa	90	DFK, BOKU	Ke, At	materials, Pics
November 2007	BOMOSA Calenders	Scientists, General public, civil servants, NGO's, private sector	Eastern Africa, Austria, Czech Republic	500	DFK	Ke, At	200 copies
November 2007	Sign posts were placed at two BOMOSA sites and the Hub at Sebeta.	All visitors	Ethiopia	10000	EIAR	Et	sign post in pieces
December 2007	Sign posts giving -Project title strategically written on stores constructed on the pier	Scientists, General public, civil servants, NGO's, private sector	Kenya and general visitors	10000	DFK	Ke, At	

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
January 2008	BOMOSA posters, Photos exhibition SNNPRS, Bureau of Agriculture, Awasa..	Exhibition visitors	Ethiopia	30000	EIAR	Et	photos
February 2008	State visit in Ethiopia (Sebeta) of the Austrian president, his wife and delegation	delegates of policy, economy and science; scientists; reporter	Ethiopia	1000	EIAR, BOKU	Et, At	booklet, pics, newspaper
February 2008	Foto documentation of BOMOSA plots in Ethiopia for Austrian presidents visit	delegates of policy, economy and science; scientists; reporter	Ethiopia	500	EIAR, BOKU	Et, At	pics
March 2008	Manual & DVD on remote sensing (GIS, GPS, LANDSAT scenes)	BOMOSA partners	Eastern Africa	14	EIAR, Egerton University, KMFRI, DFRU	CZ	Landsat data, manual, DVD, ppt
April 2008	Article in magazine "Forschen & Entdecken"	public	Austria	500	BOKU	At	article
April 2008	Hand bag, T-shirt and caps with BOMOSA logo printed.	BOMOSA partners and local community	Ethiopia	80	EIAR	Et	material in pieces
April 2008	MSc thesis "Potential influence of fish cage farming on water quality, phytoplankton biomass and plankton species composition in fish ponds: a case study in the Rift-Valley & North Shoa reservoirs, Ethiopia", F. Degefu.	Scientists & policy maker	Ethiopia	30	EIAR, OEAW	ET, At	MSc thesis
May 2008	Management briefs to the Ministry of Agriculture staff	Ministry of Agriculture, animal industry and fisheries staff	Uganda	32	DFRU	Ug	Report
May 2008	MySIL-workshop of Austrian chapter of the International Limnological Society (SIL)	Scientists	Austria	50	OEAW	Aut	poster
June 2008	Abstract in Proceeding of: XXV Conference of the Italian Society of Parasitology (SOIPA)	Scientists, students	Italy	150	UNIBO, EGU, MU, DFRU, EIAR, Sagana	I	Scientific abstract in the Proceedings of the Conference

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
June 2008	BOMOSA stand & poster presentation at international exhibition "Bridging Research, Technology and Development: Initiating an interactive stakeholders' partnership for sustainable water resource development", Kisumu, Kenya.	Scientists, NGO's, policy-maker, private sector	Eastern Africa	140	EGU, MU, DFK, KMFRI, EIAR, OEAW	Ke, At	Pics, Poster
March 2008	Manual & DVD on remote sensing (GIS, GPS, LANDSAT scenes)	BOMOSA partners	Eastern Africa	14	EIAR, Egerton University, KMFRI, DFRU	CZ	Landsat data, manual, DVD, ppt
August 2008	BOMOSA brochure (Amharic version)	Local BOMOSA community	Ethiopia	200	EIAR	Et	Brochure in pieces
September 2008	BOMOSA article in "Kisumu Workshop/Exhibition" report	Scientists, NGO's, policy-maker, private sector	Eastern Africa	200	EGU, OEAW, MU, EIAR	Ke, At	Article in Workshop/Exhibition report
September 2008	BOMOSA cages & poster presentation at Agricultural Show of Kenya under Ministry of Fisheries; Theme: Empowering people through growth in agribusiness -Nyeri, Kenya.	Scientists, NGO's, policy-makers, public, civil servants & private sector	Eastern Africa	1000	DFK	Ke, At	pics
October 2008	Poster presentation at Tropentag 2008 Conference, Competition for Resources in a Changing World New Drive for Rural Development, October 7 - 9, 2008, Hohenheim, Germany	Scientists, NGO's, policy-maker, private sector	World wide	> 700	DFRU		
March 2009	Internet magazine article "Ostafrikas Bauern ernten Fische", VET-magazine	Veterinary experts	Austria, Germany, Switzerland	>500	OEAW		
March 2009	Internet article "Ostafrikas Bauern ernten Fische", webpage of Austrian Academy of Sciences	General public	Austria	>500	OEAW		
April 2009	Daily newspaper article "Ostafrikas Bauern ernten Fische", Salzburger Nachrichten.	General public	Austria	>100000	OEAW		
May 2009	Daily newspaper article "Fish farming initiative could boost tilapia production", The Standard, Kenya	General public	Printed newspaper in Kenya, internet version World wide	> 2 million	KMFRI		
May 2009	Flyer and conference announcement for BOMOSA final Conference	Scientists, NGO's, policy-maker, private sector	Eastern Africa, world-wide	1000	OEAW		

Date of implementation	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved	Country lead	Documentation
May 2009	Teach them to fish, Czech TV documentary about BOMOSA	General public	Africa, EU	350.000	ENKI and Czech TV		
July 2009	Daily newspaper article "Villagers turn stone into fish", Daily Nation, Kenya.	General public	Printed newspaper in Kenya, internet version World wide	> 3 million	KMFRI		
August 2009	Poster "Helminth parasites of Oreochromis niloticus raised in BOMOSA cages"	Scientists	Ethiopia	> 200	EIAR		
September 2009	Magazine article "Fische ernten in Ostafrika", Weltnachrichten, September 2009	Special interest groups and development cooperation experts	Austria	>2000	OEAW		
15./16. September 09	Call for Africa FFG-Networking Day	Scientists	Africa, Europe	200	BOKU		
September 2009	Book of abstract of final BOMOSA Conference	Scientists, governmental institutions, development agencies, NGO's, policy-maker, private sector, BOMOSA plot owners	World wide	800	BOKU, OEAW, MOI		
September 2009	Daily newspaper article "Benefits, risks in cage fish farming"	General public	Kenya	>1 million	MOI, KMFRI		
October 2009	Technical manual remote sensing "RS method and manual"	students, scientists	Africa	100	ENKI		
November 2009	Article "Globales Wissen 21", coprorAID Magazin	General public	Austria	>100000	BOKU		
January 2010	Exhibition Ethiopia at Charles University in Prague, Faculty of Science	scientists, students, public	Czech Republic	5000	ENKI		

Section 3 – Publishable results

Table of publications

Publis- hing Year	Authors	Title	Journal	Issue	pages
2007	Fioravanti M.L., Florio D., Konecny R., Lorber J., Wathuta E.M., Magana A., Otachi E.O., Matolla G.K., Warugu H.W., Liti D., Mbakula R., Thiga B., Onega D., Akoll P., Waidbacher H.	Preliminary data on the parasitofauna of wild and cultured fish from Kenya and Uganda. 7th International Symposium on Fish Parasites, 24-28 September 2007, Viterbo, Italy	Parassitologia	49 (suppl. 2)	56
2009	J. M. Munguti, D. M. Liti, H. Waidbacher, M. Straif, W. Zollitsch	Effects of substitution of freshwater shrimp meal (<i>Caridina nilotica</i> Roux) with hydrolyzed feather meal on growth performance and apparent digestibility in Nile tilapia (<i>O. niloticus</i> L.) under different culture conditions.	Journal of Livestock Research for Rural Development	21 (8)	1-13
2009	Nalwanga R, Liti, D.M. Waidbacher H, Munguti J.M, Zollitsch, W .J	Monitoring the nutritional value of feed components for aquaculture along the supply chain – an East African case study	Journal of Livestock Research for Rural Development	21 (9)	Article # 148
April 2009	Hesslerová P., Pokorný, J.	Effect of Mau forest clear cut on temperature distribution and hydrology of catchment of lakes Nakuru and Naivasha.	In: Kröpfelová, L., Vymazal, J. (eds.) 7th International Workshop on Nutrient Cycling and Retention in Natural and Constructed Wetlands, 22 – 25 April 2009, Třeboň		40-44
September 2009	Hesslerová P., Pokorný, J.	Effect of Mau forest clear cut on temperature distribution and hydrology of catchment of lakes Nakuru and Naivasha. Preliminary study.	Springer Books series on Wetlands (edited by J. Vymazal)	accepted	
September 2009	Hesslerová P., Pokorný, J.	Wetland analyses in Lake Kyoga region and Kamuli district in Uganda.	Springer Books series on Wetlands (edited by J. Vymazal)	accepted	
Submitted in July 2009	Hesslerová, P., Šíma, M.	Method for detection of small water bodies based on Landsat satellite data developed for purpose of cage fish farming in Eastern Africa.	International Journal of Remote Sensing	submitted	
Submitted in August 2009	Harrison Charo-Karisa, Jonathan M. Munguti, Herwig Waidbacher, David Liti, Werner Zollitsch	Low input cage culture - towards food security and livelihood improvement in rural Kenya	Sarnisa compedium	submitted	
September 2009	Drexler S.-S., Waidbacher H. (Eds.)	Book of Abstracts (Final Conference; Machakos, Kenya; 2nd to 4th September 2009)	Universität f. Bodenkultur Universitätsbibliothek	ISBN-Number: 978-3-900962-84-5	
In prep	Asaminew K., Munguti J., Waidbacher H., Zollitsch W.	Review on locally available fish feedstuffs for aquaculture development in Ethiopia	Austrian Journal of Agricultural Research	in prep	

Publis- hing Year	Authors	Title	Journal	Issue	pages
In prep	Jonathan Munguti, D. Liti, K. Asaminew, W. Mwanja, M. Mwanja, H. Waidbacher, S. Drexler, M. Straif, B. Heimberger, K. Hammerl, R. Nalwanga, W. Zollitsch	Nutrient content of selected potential feed ingredients for inclusion in fish feeds in Kenya, Uganda and Ethiopia	Austrian Journal of Agricultural Research	in prep	
In prep	Straubinger N., M. Schagerl	Floristic aspects of kenyan ponds with different trophic levels.	Phycologia	in prep	
In prep	Straubinger N., Kaggwa M., M. Schagerl	Phytoplankton community structure related to environmental and biotic factors.	Hydrobiologia	in prep	
In prep	Straubinger N., Schagerl M., Kurmayer R.	Occurrence of Microcystins in Kenyan ponds.	Hydrobiologia	in prep	
In prep	Straubinger N., Kurmayer R.	Characterization of Microcystis clones - a comparison of morphology, microcystin structures and molecular data.	Microbial Ecology	in prep	
In prep	Bende, A. J, Mwanja, W. W, Mwanja, M	Community mobilization for promotion and adoption of BOMOSA cage fish farming systems: achieving acceptability, ownership and adoption of BOMOSA cage fish farming system at Ndolwa and Busoga High School communal water reservoirs in Kamuli, Uganda	Journal of Agriculture and Rural Development	in prep	
In prep	Bende, A. J, Mwanja, W. W, Mwanja, M	Cultural influences on fish eating as barriers to the adoption of appropriate technologies for farmed fish production in traditionally cattle keeping area in Uganda: the case of introduction of BOMOSA cage fish farming system in Nakasongola, Uganda	Journal of Agriculture and Rural Development	in prep	
In prep	Mwanja, M, Mwanja, W. W, Bende, A. J	Analyses of potential fish feed ingredients and formulation of low cost high nutritional value feed for 'low volume high density' BOMOSA cage culture of Nile tilapia based in ponds, reservoirs and temporary water bodies for rural fish production in Uganda	The Journal of Agriculture - Uganda	in prep	
In prep	Munguti, J. M	Nutrient content of selected potential feed ingredients for inclusion in fish feeds in eastern Africa region	Journal of Aquaculture	in prep	
In prep	Akoll P	Risk evaluation of parasite transmission to caged fish under the BOMOSA cage fish farming systems in Uganda	Aquaculture Review Journal	in prep	
In prep	Mwanja, W. W	Use of temporal water bodies for increased fish production for rural communities in Northern and Eastern Uganda using BOMOSA Cage Culture Technologies	Journal of African Tropical Hydrobiology	in prep	
In prep	Mwanja, M	Optimization of BOMOSA Cage Fish Farming for improved productivity and	Journal of Agriculture - Uganda	in prep	
In prep	Akoll P	Preliminary survey of the parasitofauna of wild fish within BOMOSA cage fish farming plots at Ndolwa and Kasolwe communal reservoirs in Uganda	Journal of Parasitology	in prep	
In prep	Mwanja, W. W	Socioeconomic characterization of two rural communities selected for introduction of BOMOSA Cage fish systems in Kamuli, Uganda	Journal of Rural and Community Development	in prep	

Table of M.Sc. and Ph.D. theses

Begin	Finish	Type	Title of thesis	Student	Field-work	Supervisor	Partner involved	Sponsorship
October 2004	April 2007	PhD	Utilisation of locally available feedstuffs for Nile Tilapia (<i>Oreochromis niloticus</i> L.) production in small-scale cage culture in Kenya	Munguti J.M.	Kenya	Liti D., H. Waidbacher H., M. Straif, W. Zollitsch	BOKU, MO, KMFRI	ADC
December 2006	October 2007	MSc	Availability and feeding value of selected potential feedstuffs for a sustainable fish production system in Kenya	Hammerl K.	Kenya	Elmadfa I., W. Zollitsch	BOKU, MU, DFK, KMFRI	DLE - University of Vienna
January 2007	June 2010	MSc	Effects of varying feeds formulation on growth performance of Nile Tilapia in cag-cum-pond aquaculture	Ramsauer E.	Kenya	Waidbacher H.	BOKU, MU, DFK, KMFRI	KUWI
March 2007	December 2008	MSc	Studies on occurrence of parasites in Nile Tilapia (<i>Oreochromis niloticus</i> L.) from central and eastern provinces, Kenya.	E. O. Otachi	Kenya	Wathuta E.M. & A. M. Magana	EGU	EGU/BOMOSA
May 2007	December 2009	PhD	Phytoplankton communities and cyanotoxin production in small reservoirs in Kenya.	Straubinger N.	Kenya	Schagerl M., R. Kurmayer	OEAW, MU, DFK	BOMOSA
June 2007	June 2010	PhD	Ecology of parasites of wild and cultured fish in Uganda	Akoll P.	Uganda	F. Schiemer F. & M.L. Fioravanti	UNIBO	ADC
September 2007	December 2008	MSc	Veterinary and Public health aspects in tilapia aquaculture in Kenya	Turci F.	Kenya	Fioravanti M.L.	UNIBO	UNIBO
October 2007	April 2008	MSc	Potential influence of fish cage farming on water quality, phytoplankton biomass and plankton species composition in fish ponds: a case study in the Rift-Valley & North Shoa reservoirs, Ethiopia	Degefu F.	Ethiopia	Schagerl M., S. Mengistou, Z. Tadesse	OEAW, EIAR	ADC
October 2007	April 2008	MSc	Nutritional quality of the major fish feed ingredients and commercial fish feeds from different sources in East Africa for Nile Tilapia cage culture	Nalwanga R.	Kenya	Zollitsch W., D. Liti	OEAW, BOKU, MU, DFK, KMFRI	ADC

Begin	Finish	Type	Title of thesis	Student	Field-work	Supervisor	Partner involved	Sponsorship
January 2008	March 2010	MSc	Analysis of locally available feedstuffs and formulation of diets for Nile Tilapia production in small-scale cage culture in Kenya	Heimberger B.	Kenya	Zollitsch W., H. Waidbacher	BOKU, MU, DFK, KMFRI	
January 2008	March 2009	MSc	Influence of locally available feedstuff on growth rates for Nile Tilapia (<i>Oreochromis niloticus</i> L.) production in small-scale cage culture in Kenya	Gasienica-Wawrytko B.	Kenya	Waidbacher H.	BOKU, MU, DFK, KMFRI	KUWI
January 2008	March 2009	MSc	Feeding habits of Nile Tilapia on formulated diets of locally available feedstuffs	Assmann S.	Kenya	Waidbacher H.	BOKU, MU, DFK, KMFRI	KUWI
April 2008	November 2008	BSc	Morphological and molecular identification of Clinostomatid parasites	Stanzani E.	Kenya	Caffara M.	UNIBO	UNIBO
October 2008	April 2009	MSc	Prevalence and abundance of fish parasites in BOMOSA cage systems and Lakes Babogaya and Awassa, Ethiopia	Bedanie B.	Ethiopia	Konecny R., Z. Mengistou	OEAW, EIAR, UNIBO	ADC
October 2008	October 2011	PhD	Utilisation of locally available feedstuffs for Nile Tilapia (<i>Oreochromis niloticus</i> L.) production in small-scale cage culture in Ethiopia	Asaminew Desta K.	Ethiopia	Zollitsch W., H. Waidbacher	BOKU, EIAR	ADC
October 2007	October 2009	MSc	The effect of including boiled tea leaves residues in formulated diets for Nile Tilapia, <i>Oreochromis niloticus</i> (L)	Benson Obwanga	Kenya	Liti D., Wathuta E.U., Magana A.M., Waidbacher H., Mbaluka R.	MU, DFK, EGU, BOKU	
October 2007	April 2011	PhD	Effect of Blue light on the response in three strains of Nile tilapia fingerlings	Helen Warugu	Kenya	Liti D., Waidbacher H., Mbaluka R.	MU, DFK, BOKU, EG	
October 2008	October 2009	MSc	Short term impact of thermal structure on water quality variables and fish growth in tropical reservoirs	Lukuyu R.	Kenya	Liti D., Waidbacher H., Mbaluka R.	MU, DFK, BOKU	
January 2009	May 2010	MSc	Videoanalysis of the feeding behaviour of Nile Tilapia (<i>O. niloticus</i> L.) for usage in the small-scale cage aquaculture in Kenya	C. Stoeger	Kenya	Waidbacher H.	BOKU	

Begin	Finish	Type	Title of thesis	Student	Field-work	Supervisor	Partner involved	Sponsor-ship
January 2009	January 2011	MSc	Nutrient contents analysis of locally available feedstuffs and formulated diets for Nile Tilapia (<i>O. niloticus</i> L.) production in small-scale cage culture in Kenya	C. Gutmann	Kenya	Waidbacher H., W. Zollitsch	BOKU	