Smart Fish
Secure fisheries *Secure futures*

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Programme for the implementation of a Regional Fisheries Strategy for the Eastern and Southern Africa and Indian Ocean Region

Programme pour la mise en oeuvre d'une stratégie de pêche pour la région Afrique orientale-australe et Océan Indien

SPIRULINA – A LIVELIHOOD AND A BUSINESS VENTURE

March 2011

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Implementation of a Regional Fisheries Strategy
For The Eastern-Southern Africa and India Ocean Region

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Spirulina
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A Business Venture

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Antonio Piccolo

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PREFACE

Within the context of the sustainability of artisanal fisheries in the ESA-IO region, efforts are being made to understand how traditional fishers can improve economic conditions for themselves and communities through diversification from traditional activities. This would provide supplemental and/or alternative opportunities for the fishing communities that would remove pressure from over-fished stocks, as well as provide new and exciting opportunities to improve economic returns.

Whilst this context has merit, SmartFish also provides an opportunity to review and understand potential in areas that are less developed and less understood in the region, but offer quite significant potential for investment at a small scale that is suitable to the smaller entrepreneur in the region, and notably for women to be involved.

With this in mind, this study looks at Spirulina as a new business opportunity that is recognized and has the potential for developing national and regional markets. A relatively small investment is required and the technical knowledge is fairly simple to obtain. Spirulina also provides a basic business model that is similar in process to those techniques used by regular fish farming and so links well with the burgeoning interest in the aquaculture sub-sector regionally.

SmartFish is interested to identify suitable opportunities for diversification and to provide support to pilot these opportunities in suitable areas to encourage their expansion and integration within the overall strategic regional fisheries development approach that forms the basis of the Programme. This report, which has been prepared by Mr. Tony Piccolo involved a regional assessment of potential for Spirulina growth and focused attention on western Kenya, which is presently a key area where production is starting and showing promising results.

Spirulina is a less known, but potentially interesting opportunity for increased production in the region and has a high value and an established, growing market. The opportunity is particularly relevant to women from the perspective that it is an activity that can be performed with less capital intervention and can be established close to the home. This has very interesting potential with respect to the diversification of the artisanal fishing sector and enhancement of regional trade and food security.

This report is the first step and will identify the opportunity for SmartFish to communicate the potential to the region and support pilot interventions and training in future stages of the Programme.

ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
CD4	T-cell count in the body – identifies levels of immunity in the system
CESVI	Cooperazione e Sviluppo Italia – Italian NGO working in cooperation and development
CO2	Carbon Dioxide
ESA – IO	Eastern and Southern Africa and Indian Ocean
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GLA	Gamma-Linolenic Acid
HIV	Human Immunodeficiency Virus
IFAD	Innovative Fund for Agricultural Development
KEBS	Kenya Bureau of Standards
KMFRI	Kenya Marine and Fisheries Research Institute
IIMSAM	Intergovernmental Institution for the Use of Micro-Algae Spirulina against Malnutrition
MoH	Ministry of Health
NGO	Non-Government Organization
pH	level potential Hydrogen (amount of acid and alkaline in water)
PBR	Photo Bio-Reactor
PV	Photo Voltaic
RNA	Ribonucleic Acid
TASO	The AIDS Support Organizations, Uganda
UAC	Uganda Aids Commission
UK	United Kingdom
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNICEF	United Nations International Children's Fund
USDA	United States Department of Agriculture
WFP	World Food Programme
WHO	World Health Organization

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The author wishes to thank the following people who contributed and assisted in giving information for this report. The list below has been compiled in the order that the people were met and in no way reflects their overall contribution. Each and every individual has contributed valuable information to the report and although most of the information has gone into the report, some has been retained by the author and SmartFish for future reference;

Dunga Spirulina:	Mr. Jagpal Sandhu
KMFRI – Kisumu:	Dr. Ojwang Raphael Okeyo
IIMSAM:	Frederick Lwamba Elhaan Egeh Job Kongula Grace Nyamogo
Galaxy – Kakamega:	Paul Kisiangani
UNICEF:	Richard Oktech
CESVI:	Laura Kaddu
Uganda Aids Commission:	Dr. David Tigawalana
TASO:	Mr. Robert Ochai
Uganda MoH:	Dr. Joshua Musingusi

LAYMAN'S SUMMARY

This report presents the findings of a mission that examined the requirements for developing a communication plan to support diversification of artisanal fisheries, with specific focus on Spirulina production.

Spirulina is a high value nutritional product whose market potential is growing in both developed and developing countries. Its high protein, vitamin, mineral and micro-nutrient content makes it an ideal food supplement for the malnourished as well as the health conscious who wish to boost their immune systems. Therefore markets for this product are to be found in the ESA-IO region as well as in developed countries in Europe, North American and Asia.

Spirulina production is established in the ESA-IO region in limited specific areas where climatic conditions favour its growth. This study analyses current production with a focus on enhancing production in the project region. Specific detail and attention is given to production in western Kenya where a network of producers strives to keep up with national and international demand.

RÉSUMÉ DES NON-INITIÉS

Ce rapport présente les conclusions d'une mission qui a examiné les exigences en matière de développement d'un plan de communication pour soutenir la diversification de la pêche artisanale, avec un accent particulier sur la production de Spiruline.

La spiruline est un produit de haute valeur nutritionnelle dont le marché potentiel est de plus en plus dans les pays développés et en développement. Sa haute teneur en protéines, vitamines, minéraux et oligo-éléments contenus en fait un complément alimentaire idéal pour les enfants malnutris, ainsi que la santé qui souhaitent renforcer leur système immunitaire consciente. Par conséquent les marchés pour ce produit se trouvent dans la région ESA-IO ainsi que dans les pays développés en Europe, en Amérique du Nord et en Asie.

La production de Spiruline est établi dans la région AfOA-OI dans limitées des domaines spécifiques où les conditions climatiques favorisent sa croissance. Cette étude analyse la production actuelle en mettant l'accent sur la production amélioration dans la région du projet. Détail spécifique et une attention est accordée à la production dans l'ouest du Kenya, où un réseau de producteurs s'efforce de répondre à la demande nationale et internationale.

EXECUTIVE SUMMARY

Spirulina is a micro-algae and as such has been growing naturally in our environment for millions of years, it is a tough plant able to withstand harsh growing conditions, in fact the micro-algae cell never really dies it goes dormant when weather conditions are not favourable, and as soon as these change and the environment is once again suitable for growth, spirulina begins growing and reproducing again.

Naturally growing spirulina can be found in high alkaline lakes and in general it is said that where flamingos are, spirulina is sure to be found. The Mexicans where the first to discover its wonderful health properties and in the 16th Century the Aztecs around Lake Texcoco were known to feature it on their dinner tables. In the 1940's a French phycologist discovered spirulina to be growing in Africa; Lake Chad and the lakes of the Rift Valley in Eastern Africa were the main areas where spirulina thrived.

The Kenembus tribe of Chad harvest the algae from the lake and dry it in the sun in a cake shape form, which is locally called "dihe". This is sold to the markets and has become a staple diet for some of the communities living around Lake Chad. In a study on the correlation between poverty and malnutrition 10 countries were taken as examples. Of those

10 countries 9 were found to have a direct link between poverty and malnutrition – Chad was the only country that was poor but had no malnutrition.

Modern day technology allows us to grow spirulina in man-made machines called Photo Bio-Reactors (PBR) – these machines are ideal to grow the algae in conditions where the natural habitat would otherwise not permit the cell to normally grow. Although briefly mentioned in this study PBRs are not ideal to grow and harvest spirulina in the ESA-IO region for primarily two reasons.

Firstly the initial start-up costs are too high – and although most PBRs promise high yields in micro-algae production in reality only some are able to achieve those promises. Secondly most of the region is favourable to spirulina growth without the use of expensive machines and it can be cultured and harvested fairly easily in man-made basins and ponds.

Spirulina is a highly nutritious natural substance, which has in recent years gained, once again, interest in both developing and developed countries. It is very in high protein content; yields 20 times more protein per acre than soybeans, 40 times more than corn, and over 200 times more than beef make it an ideal food supplement for everyone. More awareness needs to be raised so that people understand what spirulina can do, its high protein, vitamin, mineral and micro-nutrient properties are good for both the ill (HIV/AIDS), malnourished children and infants and for the health conscious. In some cases spirulina has been incorrectly marketed as a medicine giving people, particularly the ill, false hope – in fact spirulina is a food supplement whose main benefit is the boosting of the immune system.

RÉSUMÉ EXECUTIF

La spiruline est une micro-algue et en tant que telle a pousse de plus naturellement dans notre environnement depuis des millions d'années. C'est une plante robuste capable de résister à des conditions de culture difficiles, en fait, la cellule de micro-algues ne meurt jamais vraiment, elle se met en sommeil lorsque les conditions météorologiques ne sont pas favorables, dès que celles-ci changent et quand l'environnement est a nouveau convenable pour la croissance, la spiruline commence à grandir et se reproduire.

Naturellement croissante spiruline peut être trouvée dans les lacs alcalins élevés et, en général, il est dit que là où les flamants sont, la spiruline est sûre d'être trouvée. Les Mexicains, sont les premiers à découvrir ses propriétés merveilleuses et de santé au 16ème siècle, les Aztèques autour du lac Texcoco étaient connus pour l'avoir placé sur leur table. Dans les années 1940 c'est un psychologue français qui a découvert la spiruline poussant en Afrique. Le lac Tchad et les lacs de la vallée du Rift en Afrique de l'Est ont été les principaux endroits où la spiruline a prospéré.

La tribu Kenembus du Tchad récolte ces algues à partir du lac et les font sécher au soleil dans sous une forme de gâteau qui est appelé localement "dihé". Ceci est vendu sur les marchés et est devenu un régime stable pour quelques-unes des communautés vivant autour du lac Tchad. Dans une étude sur la corrélation entre la pauvreté et la malnutrition, 10 pays ont été pris comme exemple. Sur ces 10 pays 9 ont été trouvés à avoir un lien direct entre la pauvreté et la malnutrition - Le Tchad a été le seul pays qui était pauvre, mais qui n'a pas souffert de la malnutrition.

La technologie moderne nous permet de grandir la spiruline dans les machines artificielles appelées photo bio-réacteurs (PBR) - ces machines sont idéales pour la croissance de l'algue dans des conditions où l'habitat naturel, autrement, ne permettent à la cellule de se développer normalement. Bien que brièvement mentionnés dans cette étude les PRBs ne sont pas idéales pour cultiver et récolter la spiruline dans la région AfOA-OI, principalement pour deux raisons.

Tout d'abord les initiales des coûts de démarrage sont trop élevés - et bien que la plupart des COV promettre des rendements élevés dans la production de micro algues, en réalité seulement certaines sont capables de réaliser ces promesses. Deuxièmement la plupart des régions sont favorables à la croissance de la spiruline, sans l'utilisation de machines coûteuses et peuvent être cultivées et récoltées dans des bassins artificiels et les étangs.

La spiruline est une substance naturelle hautement nutritive, qui a gagné ces dernières années une fois de plus un

certain intérêt à la fois dans les pays en développement et les pays développés. Il est très en haute teneur en protéines, les rendements 20 fois plus de protéines par acre que le soja, 40 fois plus que le maïs, et plus de 200 fois plus que le bœuf en font un complément alimentaire idéal pour tout le monde. Plus de sensibilisation doit être relevée afin que les gens deviennent plus conscients de ce que la spiruline peut faire, sa haute teneur en protéines, vitamines, minéraux et ses propriétés oligo-éléments sont bons à la fois pour ceux qui sont malades (VIH / sida), les enfants souffrant de la malnutrition et les nourrissons et pour ceux qui sont conscients de leur sante. Dans certains cas, la spiruline a été incorrectement commercialisé comme médicament et a de donné aux gens malades de faux espoir- en fait, la spiruline est un complément alimentaire dont le principal avantage est la relance du système immunitaire

1.0 INTRODUCTION - WHAT IS SPIRULINA?

Spirulina (Arthrospira platensis) is a naturally occurring blue-green micro-algae which grows and thrives in warm water alkaline lakes. Wild grown spirulina sustains flamingos in the East African Rift Valley lakes and has the strength and ability to thrive in conditions where other algae cannot grow. It is a single celled organism that turns sunlight into micronutrient life energy. It is one of early life forms originating more than 3.6 billion years ago, and its spiral shape is what gives it the common name of spirulina.

Spirulina has amazing properties and in many ways can be considered a Super Food. It contains the most remarkable concentration of nutrients known in any food, plant, grain, or herb. It's composed of 60% highly digestible vegetable protein, has extremely high concentrations of beta carotene, vitamin B-12, iron and trace minerals, and the rare essential fatty acid GLA – Gamma-Linolenic Acid (which people who have not been breast fed do not have). It has a balanced spectrum of amino acids, cleansing chlorophyll, and the blue pigment, phycocyanin.

All the essential vitamins and minerals a body requires can be provided by spirulina, these provide a variety of benefits for the human body, like nourishment, mental clarity, assisting in cancer recovery, depression help and many others. Several scientific studies show spirulina to have the ability to inhibit viral replication; in particular it was found that 5-10 mg/ml of spirulina will inhibit the HIV-1 virus otherwise known as the AIDS virus.

Globalization has also streamlined the normal business of states whereby the public sector emerges as regulator and facilitator to fast track a business friendly environment, equal opportunities for all and social justice. The private sector is empowered as the growth engine. Innovative financial concepts such as Public-Private Partnerships have become instrumental in the procurement of economic infrastructure and efficient logistics to connect local industries to international trade. This policy framework is also relevant for the development of the fisheries sector of an insular economy.

From a marketing perspective, fish is an end product and/or an intermediate input in the supply chain to produce value added fish and fish products for end consumers. No enterprise irrespective of type or scale is immuned or isolated from international trade. Self employed actors in the fisheries sector are in fact household or micro enterprises that have to be empowered by all means to build a resilient business enterprise at the grass-roots level of the national economy.

Fish stocks are part of the biogical wealth of a nation and their economic rent is a function of their respective value chain or maximisation of value added. Common property rights or open access is the main cause for depletion of fish stocks and degradation of the marine ecosystem in coastal fisheries. It negates value chains and degenerates into a vicious circle of poverty and the paradox of miseries in the midst of plenty among the fisher communities. Actually coastal fisheries feed everyone – the traders, processors, exporters and consumers – except the fishers.

The methodology of VCA was initially devised as an analytical tool to examine efficiency at each sequence of the value chain of an industrial or marketing function. This method is currently applied to assess the value added or profitability of seafood industries and to study the economic viability of specific projects. In small scale fisheries, VCA can be instrumental in promoting judicious utilization of scarce fish stocks through appropriate product and market development. The main objectives of this study for the fisheries sector of Rodrigues include:

- Appraisal of the different value chains operating in the fisheries sector and their enabling environment using a systemic approach.
- An analysis of the supply chains– production , processing, marketing - to assess the revenue flow and economic efficiencies.
- Evaluation of future value chain opportunities and constraints of the fisheries sector within the perspectives of future fisheries development and management policies.

- Recommendations to ascertain sustainable development of the fisheries sector as a driving force for socio-economic benefits of the regional economy.

1.1 WHAT ARE MICRO-ALGAE?

Micro-algae are one of the smallest, most ancient and robust organisms living on Earth and one of the tiniest plants, which alone produce about 60 percent of the Earth's oxygen. They have survived some of Earth's harshest conditions for several billion years due to their incredible and robust cell wall.

All the essential vitamins and minerals can be provided by micro-algae. The most widely used micro-algae for food and nutrition are 2 particular species, Spirulina (Arthrospira platensis), and Chlorella (Chlorella pyrenoidosa and Chlorella vulgaris), these contain roughly 60 percent protein and are grown and harvested in Africa to combat HIV/AIDS and malnutrition particularly in infants, children and pregnant women.

Micro-algae come in a variety of strains (variants); each strain has different proportions of lipids (fats), starches and proteins. Depending on this proportion the algae can be used to produce;

1. Food for high protein intake, used for malnourished children in developing countries and HIV/AIDS patients, but also a growing market exists in developed countries, such as Australia, the USA, Canada etc. as a food supplement and immune booster. Strains such as Arthrospira platensis and Arthrospira maxima are commonly used for this.

2. Oil for bio-crude if the lipid content is adequately high strains such as Botryococcus braunii or Chlorella ellipsoidea can be used for this.

3. Ethanol or biogas, through fermentation if the variant contains more carbohydrates; Porphyridium cruentum and Spirogyra sp. can be used for this.

This report will focus on the growth and production of one particular strain of micro-algae (Arthrospira platensis); commonly known as Spirulina. Spirulina grows naturally in warm water alkaline lakes with high pH values it sustains the life of the flamingos in the area and is renowned for giving them their distinct pink colouring.

Besides growing naturally in lakes Spirulina can be and is grown in Photo Bio-Reactors (PBR) and in man-made artificial ponds or basins. With the right environmental conditions a pond can yield 10-12 grams per square metre. The right conditions include;

- Basins in order to contain the water (about 50 to 60 cm high) and the culture (algae)
- Adequate sunlight (below 20oC growth is practically nil and the optimum temperature is between 35oC and 37oC, (higher temperatures will destroy the nutrients)
- A cover for the pond (to avoid contamination and cross-breeding)
- Salts to soften the water and to increase the pH value (more alkaline)

1.2 USES OF SPIRULINA

Due to its high quantities of minerals, vitamins and micro-nutrients, Spirulina has been mainly used to combat malnourishment and assist HIV/AIDS patients Africa. However in the last few years Spirulina has seen a growing market amongst the health and fitness conscious. Its high protein and nutrient content make it an ideal food supplement and an immune booster.

Spirulina is particularly effective to relieve the suffering of HIV/AIDS patients. The way it works is that when the virus attacks a cell it attaches itself to the cell membrane (outer wall) penetrating it, spirulina does not allow the virus to penetrate and hence infect the cell. The virus therefore can no longer replicate itself and the body's natural defence mechanisms will eventually discard it, this can assist AIDS patients lead a more normal life.

10 benefits from taking 5-10 grams of spirulina every day;

- Increases the CD4 count – Strengthens the immune system (particularly useful for HIV/ AIDS patients.
- Increases RNA (Ribonucleic acid) in the brain for more energy
- The beta carotene (contains 10 times more that of carrots) is an excellent source of disease fighting antioxidants, and is also good for healthy eyes and vision.
- Contains vegetable protein and amino acids to build muscle
- High concentration of B Vitamins; which not only break down carbohydrate and lipids but also maintain cardiovascular health.
- It is also an excellent anti-inflammatory, which is an essential benefit to arthritis patients and prevents heart disease.
- Contains anti-aging properties.
- Improves digestive health
- Contains easy to absorb iron supplements ideal for women and children.
- Reduces cancer with antioxidant protection

What some Institutions and Organizations have said about spirulina;

- The Immune System Miracle Worker (San Francisco Medical Research Foundation)
- Worlds' Most Powerful Food (biotech-firm.com)
- Spirulina is the most ideal food for mankind (United Nations Recommendation)
- Spirulina: Food for the future (Publication by the USDA – United States Department of Agriculture).
- "There is a need for both national governments and inter-governmental organizations to re-evaluate the potential of Spirulina to fulfil both their own food security needs as well as a tool for their overseas development emergency response efforts" - The UN-Food and Agriculture Organisation (FAO) Report on Spirulina 2008.
- "For WHO, Spirulina represents an interesting food for multiple reasons, rich in iron and protein, and is able to be administered to children without any risk. We at WHO consider it a very suitable food." - United Nations World Health Organization (WHO), Geneva, Switzerland June 8Th, 1993
- Spirulina- was declared by the United Nations World Food Conference of 1974 as the best food for the future.

1.3 SPIRULINA AND FISHERMEN

With world fish stocks being depleted and highly competitive fish markets, spirulina production offers a way for fishermen to diversify from fishing. With some basic knowledge, spirulina can be grown and harvested quite easily; the essential requirements are quite basic and a reasonable size pond 6m x 80m can yield as much as 5kg of dry spirulina a day. Shelf price of Spirulina varies from Euros 70 / kg (local Kenya market) to Euros 200 / Kg (USA/Australia/UK). The protein content and quality of the spirulina are a determining factor in evaluating its market price, the higher the micro-nutrient/protein content the higher the selling price.

This could be a worthwhile investment for fishermen as an alternative / complement to fishing particularly in lake regions of central and southern Africa as well as the Indian Ocean region where water is available.

KMFRI – Kenya Marine and Fisheries Research Institute in Kisumu, Kenya is very keen to pursue the idea of empowering fishermen with knowledge and capacity on how to grow spirulina as an alternative venture to fishing when stocks are down or bans are put in place on fishing in Lake Victoria, for example.

IIMSAM - Intergovernmental Institution for the Use of Micro-Algae Spirulina Against Malnutrition, also based in Kiusmu, organises courses on how to grow and harvest spirulina in ponds and basins. Cultures to start your own farm can be purchased from producers like IIMSAM, Dunga Spirulina or Galaxy at market prices or online.
The course offered by IIMSAM includes;

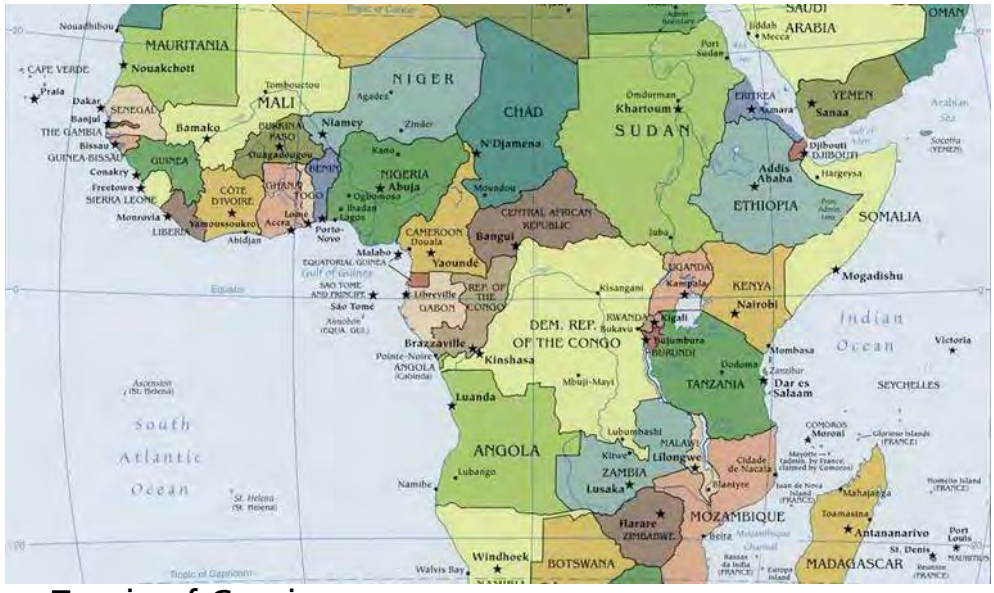
a. An introduction to Spirulina,
b. Spirulina cultivation, maintenance, production and processing,
c. Type of basins
d. Spirulina Medium cultivation and maintenance
e. Harvesting
f. Processing
g. Spirulina benefits and
h. Marketing (Jagpal Sandhu)

Fishermen are equipped with the expertise and the knowledge on how to better handle and manage fish and water products, and furthermore the basic principles of pond grown and harvested spirulina are similar to growing tilapia or other fish in an aquaculture environment. Growing spirulina in a pond could also be an introduction to basic aquaculture for fishermen.

2.0 SPIRULINA IN THE ESA-IO REGION

Temperature is a determining factor in spirulina growth and production, with an optimum temperature range of 200 – 350 C the places to grow spirulina are relatively confined to the below map. Regions between the Tropic of Cancer and the Tropic of Capricorn provide suitable temperature ranges and are suitable for spirulina production as long as other growing conditions are met.

Tropic of Cancer



Tropic of Capricorn

2.1 What's in place

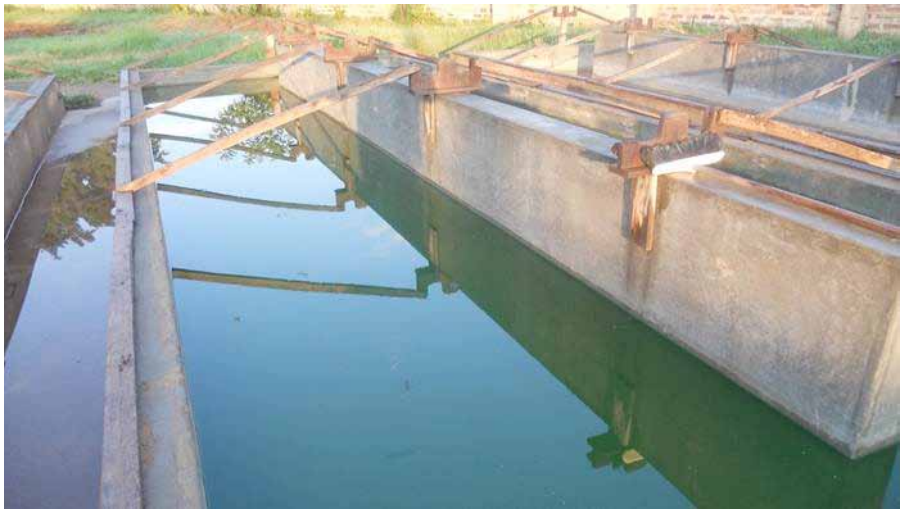
Besides the natural growing areas around Africa favourable to spirulina growth, the main hub for spirulina production is Kenya. In particular western Kenya around the Lake Victoria region is where most of the African spirulina is presently cultivated. Kenya's spirulina production is mainly for local markets for the ill and malnourished, although some of the production is aimed at more high end users, which until now have also been restricted to within Kenya.

All the spirulina in western Kenya is produced in open ponds made of polished cement or basins lined with thick polyethylene yellow plastic. The latter are much more cost effective in the short run but have proven to be more expensive in the long run due to the wear and tear of the polyethylene material. One of the ponds situated at Dunga spirulina has a fixed paddle wheel; this allows constant movement of the spirulina strains in the water to allow every cell to photosynthesise, in other cases the spirulina is agitated in the water with the aid of a broom twice every hour.

2.2 What's required to grow Spirulina – The Farm

Once an appropriate site is identified, which meets all the climatic requirements, basins or ponds need to be built. These ponds should be about 3 to 4 metres wide and can be as long as 100 metres (the larger they are the more economical the enterprise will be). The most economical ponds are the ones made of polyethylene and resemble plastic bags hanging off wooden structures (see picture below), however as economical as they may be at start-up they have been proven to be more expansive to maintain due to the wear and tear of the polyethylene material.

The polished cement ponds in the end prove the be the most cost effective, particularly with the fact that a paddle wheel can be put in place which could be solar powered hence reducing overall costs



A polyethylene cover over the pond or better still a greenhouse around the ponds could increase temperature, decrease evaporation, decrease contamination and decrease cross-breeding – all favourable to micro-algae growth.

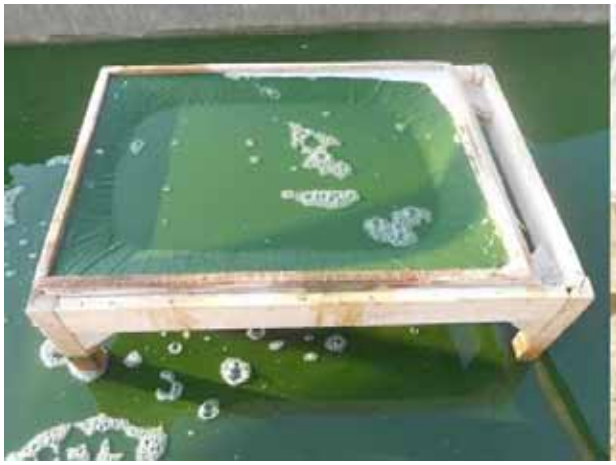
Water requirements are the most important step to growing spirulina, and although spirulina can grow in a variety of types of high alkaline waters the following "ingredients" are required;

- Sodium bicarbonate (if direct CO_2 is not available)
- Magnesium sulfate
- Potassium nitrade
- Citric acid
- Common salt
- Urea
- Calcium chloride
- Iron sulfate
- Ammonium sulfate

The pH should be around 10 at 200 C – normal tap water is generally around pH 7.

Other facilities required are;

- Harvesting basins
- Drying rooms or racks
- A room to analyse the spirulina flakes and transform them into powder and/or capsules.



Harvesting Spirulina

Drying Spirulina in racks

Grinding machine to powder spirulina

Capsules made at the Galaxy Centre in Kakamega

2.3 Where and Who

Spirulina in the ESA-IO region is mainly concentrated in Kenya, with the largest production facilities in Kisumu in the Nyanza province west of the country and in Kakamega about 2 hours north of Kisumu. There is also a research laboratory with some production on the south of the island of Madagascar.

2.3.1 Dunga Spirulina

Dunga Spirulina is a privately owned Spirulina farm situated on the outskirts of Kisumu in a village called Dunga. Jagpal Sandhu is the owner and the farm, which is made up of 4,500 sq. m ponds for a total of 2000sq. m and has a production potential of 20kgs of dry spirulina per day (10 grams per sq. m per day). Due to lack of resources current production is at about 5 kg a day.

Dunga Spirulina caters for the higher end market and sells its product in the health food sections of Nakumatt supermarkets in Kenya. Also it is available in the following:

- Healthy U Stores Countrywide (Kenya),
- Healthy U in Nairobi – Junction, Sarit Centre, Yaya Centre, T-Mall, Westgate, Village Market.
- Healthy U Express Stores inside Nakumatt: Junction, Karen, Ngong Road, Mega, Lifestyle, Village Market,

Westgate, Embakasi.
- Healthy U in Kisumu – Nakumatt Nyanza and Mega City.
- Healthy U in Mombasa – Nyali and Likoni.
- Zucchini in Naiorbi – ABC Place, Junction and Village Market,
- Elixir Health in Village Market – on top of the food court.
- Patsons Chemist in Swan Centre, and Maruti Pharmacy in Kisumu

Dunga Spirulina would like to expand its production and move into the international market, however proper analysis of the product would have to be made to match international standards and import permits and duty taxes are making this currently impossible.

Mr. Sandhu has envisioned a new "green" plant where all the power could be taken from the sun through the use of solar panels. A complete energy balance study would have to be made in order to see if this would be feasible and economically viable.

2.3.2 IIMSAM

IIMSAM is an Intergovernmental Organization established to fight hunger and malnutrition through the use of Spirulina. www.iimsam.org. IIMSAM currently produces about 3 kg a day of Spirulina powder for a total of 60kg a month (20 day monthly production). The potential however, is much higher (10 ponds are available) but due to the lack of water and the increased evaporation over the summer months only 1 pond is functioning. Each basin which measures 3 x 15 metres requires about 12,000 litres of water that requires constant top-up especially during the summer months.

IIMSAM's feeding programs are renowned throughout western Kenya and on peak production IIMSAM provides Spirulina for about 150-200 malnourished children, as well as HIV/AIDS patients. A healthy body requires 10 to 12 grams of Spirulina, malnourished children and HIV/AIDS patients require a lot more. In order to maintain this high level of production water is required to fill the ponds and boost production.

IIMSAM is situated in Kisumu near the newly built International Airport and is about 3 to 4 km from the Kisumu shores of Lake Victoria. The only way to transport water to the site is with large water trucks which have been proven to be unreliable and costly.

A more cost effective system and one which would provide IIMSAM with a constant flow of water would be to build a well on the premises. The well would be roughly 120 metres in depth and the following table provides an estimate of the cost involved. (Technical specifications are in Annex IV of this document)

Item	Description	Amount in (Euros)
1	Survey and Report	350
2	Drilling Works	9,650
3	Supply and Installation of submersible pump	2,500
4	Construction of 1m Tank-Tower Pump House	5,500
5	Plumbing works	1,000
6	Electrical Installations(Pump House)	750
Total		19,750

IIMSAM are the centre for Spirulina production and have assisted and trained through their training facilities all the producers in Kenya including Mr. Sandhu (Dunga Spirulina) and Galaxy in Kakamega, who has sent over 32 students there to be trained in Spirulina production.

2.3.3 Galaxy – Kakamega

Galaxy is situated in Kakamega about 50km north of Kisumu, it is a youth based organization that produces Spirulina and is made up of various units of Spirulina production in and around the township of Kakamega;

Two of these units are situated at the University of Masinde Muliro – University of Science and Technology - whose facility produces around 1kg a day of dry powdered spirulina, Galaxy is in close partnership with the Kenya National Federation of Agricultural Producers.

One unit is run by Prof. Paul Kisiangani (lecturer at the Universtiy), total production about 250gr or dry Spirulina powder a day.

Two more units are situated in Bungoma about 50km north of Kakamega. The Bungoma facility produces about 500gr of spirulina and is receiving government support for marketing and product development through IFAD (Innovative Fund for Agricultural Development).

Galaxy's total production is therefore almost 2kg a day of pure powdered spirulina, which is mainly used to combat malnutrition. The rest is sold either in powdered form or converted into capsules for easy consumption. Galaxy like the other producers in Kenya (Dunga and IIMSAM), has received the Kenya Bureau of Standards certification for food safety, which is a minimal requirement for food products in Kenya. Other tests are required for the spirulina to determine its protein content and a heavy metal test, but as of the time of writing this report the KEBS – Kenya Bureau of Standards could not provide these tests due to a mechanical fault in their testing system.

The two units near the university compound are producing spirulina inside greenhouses. The greenhouses allow the micro-algae to thrive due to the increase in temperature, decrease in cross-breeding and decrease in contamination. Temperatures need to be carefully monitored when using the greenhouse system due to the fact that temperatures within a greenhouse can get very high and for optimum spirulina production temperatures should not go over 38-40oC. The ponds in Kakamega measure 7m x 4m and produce in total about 1kg of spirulina a day.

2.4 What is working and what isn't

Micro-algae should not be harvested from lakes or oceans, as this would disrupt the ecological biodiversity of the environment, rather it should be grown in man-made artificial ponds to ensure not only a continuation of production, but also the establishment of a controlled environment for the algae to grow and thrive.

The main debate over growing and harvesting micro-algae is how and where to grow it. Some climates favour the growth process yet others don't, which is why machines called Photo Bio-Reactors have been used in some areas of the world where climates are less favourable to algae growth. PBR's are very expensive but can guarantee a good harvest even in tough environmental conditions, the algae grows in a closed and controlled environment, so there is no contamination or cross breeding. PBR's are generally used in climates where temperatures are too low for micro-algae growth. However some trials have been made in Kisumu using PBR's, these proved unsuccessful due to the quality of the PBR and its harvesting mechanism. All spirulina production in Kenya is made with open pond systems. Due to the favourable climate in these areas it is not recommended to attempt growth in PBRs.

All spirulina produced in Kenya (Kakamega, Dunga and IIMSAM) has been tested by KEBS (Kenya Bureau of Standards) for food safety. Analysis of protein content and a test for heavy metals content is required to determine which of the products contains the most protein and therefore which of the three systems works best for spirulina production in this area.

3.0 PRODUCT FORMS AND MARKETS

3.1 Spirulina products

Spirulina is a green dry powder, naturally very dense and difficult to dissolve in cold liquids unless very well ground or pulverised. Mixed in warm foods or drinks is ideal being careful not to destroy the properties of the powder by mixing with foods that are too high in temperature (not over 350 C).

The powder can be sold as is and consumed in its natural form (10 grams or more a day or 2 teaspoons), or capsules can be produced for easy intake. Each capsule contains 0.5mg so around 20 capsules should be taken to reach the recommended dosage of 10 grams.

Spirulina powder could be used in juice and health bars, where you can obtain a blend of juices with an extra teaspoon or 2 of spirulina as a booster. Juice companies such as Boost Australia www.boostjuice.com.au could implement this increasing demand while creating awareness.

3.2 Overview of regional markets

The 10 major benefits of spirulina are listed in paragraph 3.2 of this document. They outline the principal benefits of spirulina and hence divide the market for the product into two sectors i.e. the malnourished/HIV segment, which includes NGOs and other institutions; and, the private sector, which is the health conscious, sportsmen and women as well as people who just wish to boost their immune system and live a healthier life.
For the time being, due to a lack of funds and resources the amount of spirulina produced in western Kenya cannot keep up with regional demand; an increase in production would be necessary to fully open the market to other countries in the region. Dunga spirulina has made an attempt to sell its product to Nakumatt (retail supermarket) in Uganda, but financial constraints have prevented this from happening as well as problems finding a reliable distributor.

Potential markets could also be the United Nations and the Humanitarian Organizations, who work with malnourished children and HIV/AIDS. Organizations such as WFP, UNAIDS and UNICEF could potentially buy the spirulina in some kind of drinkable form (tetra-pak spirulina drink) and distribute the product to their beneficiaries.

3.3 Overview of exports

There is much potential to export Kenyan spirulina, however production would have to be boosted to meet market demand. The current production rate in Kenya is not sufficient to meet demand from the regional market; a lack of Resources is currently preventing this from happening in Kenya. Furthermore, since spirulina is a food supplement, importing countries would have their own rules and regulations on food imports; this this would be a challenge to be surpassed, potential markets outside Africa would need quality standards to be met that would impose higher costs on production.

In Europe, proper analyses would have to be obtained (which is relatively expensive), and an import permit would be required, which can only be given based on the analysis made. Duties and taxes are an extra which the exporter would have to face. In Australia for example there is a high demand for spirulina but Australians are only buying Australian grown spirulina, for two reasons;

1. Many people are not even aware that spirulina is grown elsewhere, and
2. Restrictions and demands imposed on imports from other countries are quite demanding

4.0 TYPICAL SMALL SCALE INVESTMENT REQUIREMENTS

4.1 Operational requirements

4.1.1 Technical inputs

Since spirulina is essentially a plant which grows in water, the technical inputs to set up a spiurlina farm are quite basic. On average 1 sq. m of water will produce 10 grams of spirulina, so to produce 1000 grams of spirulina (or 1kg) you require 100 sq. meters of pond roughly a pond 5 metres wide by 20 metres long. A pilot pond 500sq. m. would be approximately 6 metres wide by about 85m in length. For this you require:

- Land with a high boundary wall (fence) to avoid intruders
- Lighting
- PV solar panel
- Raceway pond with paddle
- Culture pond – where the actual culture is tested for growth
- Harvesting station and dryer room
- Infrastructure – office, guard house, admin building etc./ packing and grinding unit
- Laboratory for testing.

4.1.2 HR requirements.

The facility would require a farm manager to manage the overall running of the farm, a lab operator, a packaging manager plus two staff for each pond (2 shifts) for quality control of ponds and for daily harvesting and two night watchmen (guards) for two shifts. In total the farm would employ seven staff. It is obvious that as the ponds increase in number so too would the number of staff dedicated to working the ponds.

4.1.3 Other operational requirements

As mentioned above a PV solar panel would considerably lower the cost of the plant and would make the plant totally CO2 neutral. Furthermore micro-algae absorb double their own weight of Co2, so for every tonne of micro-algae produced you have mitigated climate change and absorbed two tonnes of Co2.

4.1.4 Marketing and distribution requirements

Kenya Bureau of Standards permits from other countries and a promotional campaign to raise more awareness about Kenyan spirulina

4.1.5 Risks in success

In order to have a successful spirulina production, from a technical perspective, certain things need to be in place. A good and healthy supply of "soft" water, high in alkaline (with the right nutrients). The correct atmospheric temperature between 15 and 35 degrees Celsius, but ideally the algae thrives on temperatures between 30 and 35 degrees, (in lower temperate areas the use of a greenhouse has proven to be successful in increasing the temperature). Care has to be taken and water constantly checked to avoid cross-breeding and contamination from nearby water sources (lakes, rivers etc.). Rain is beneficial as it compensates for evaporation, however heavy torrential rains can cause damage to the pond and allow the water to overflow causing culture loss.

A smaller pond containing a sample of the culture should always be kept in a safe place so that if the culture in the large pond dies or becomes contaminated you will always have a pure culture growing. The pure culture can always be sold to potential spirulina producers for extra revenue.

Other risks that can prevent success of a spirulina farm are market conditions and supply and demand. Western Kenya has the potential to become a world hub for spirulina production, however advocacy and general awareness of Kenyan and African spirulina needs to be made public in order for demand to increase, whilst at the same time assistance should be given to the region and to farmers to increase production.

4.2 Financials – see Annex IV for a full breakdown of costs.

4.2.1 Approximate capital costs for a pilot farm

The approximate capital costs for a pilot spirulina farm keeping in mind a 6m x 80m pond (around 500sq. m) in total would be around Euros 60,000. This will vary from area to area and depending on land costs. The bulk of the costs (Euros 39,000) are in the shared infrastructures and these can vary too depending on the cost of labour and materials in the country of production.

4.2.2 Approximate operating costs for a pilot farm

Operating costs can vary as well from location to location; this will depend primarily on labour costs. An approximate indication is given in Annex IV of Euros 1,370 which includes the cost of buying the culture (seed) which can vary on the market anything from Euros 80 - 150.

4.2.3 Potential revenue

Based on a 25 day month, a maximum production of 5kg per day and a wholesale price (Kenya price) of Euros 50 per kg, the total revenue is Euro 4,500 per month, less monthly expenses would yield a profit of almost Euro 3,000 – this would mean the payback time for your investment would be approximately 20 months, Euro 3,000 X 20 months = Euro 60,000 (initial investment cost)

Economies of scale would mean increasing the amount of ponds and production while marginally increasing your land and labour costs would make the venture much more fruitful. The advantages of growing spirulina in Africa is that the price can be kept low compared to other producers worldwide.

Some side revenue could also be made by selling culture and selling carbon credits (micro-algae absorb 2 tonnes of Co2 per tonne produced). This will depend on your countries legislations on carbon credits.

5.0 RECOMMENDED NEXT STEPS FOR PILOT PROJECT IN ESA-IO REGION

5.1 Overall recommendation

1. The overall recommendations are as a first step to raise awareness through the SmartFish focal points to all the SmartFish beneficiary countries. This can be done by organising a training course at IIMSAM for Focal Points where a full detailed course on spirulina production and marketing can be done. The course would focus on production systems and marketing of the product giving an indication of where the best markets are and where market restraints exist.

2. Laboratory tests for spirulina in a respected lab facility in Africa (preferably SA) or Europe. These tests should not only include microbiological tests for food safety but also water quality, protein content and tests for heavy metals. This would ensure the product to be fit for other markets particularly external markets, although most countries would still require their own lab tests to be made in order to import the product. It is recommended that these tests are done for all three producers of spirulina in western Kenya – IIMSAM, Dunga Spirulina and Galaxy.

3. If necessary and if in agreement with the producers, set up a cooperative where all the spirulina produced in Kenya can be brought together and marketed to the international community. This would bring together all the producers and make the region a sort of hub for spirulina production, enhancing marketing potential and awareness.

4. Assist IIMSAM with a new water pump or alternatively a supply of water for all their ponds (10 in total).

5. Assist both Galaxy and Dunga Spirulina to enhance their production.

5.2 Possible locations for Pilot Spirulina Farm

Due to the expertise and knowledge in the area, western Kenya (Kisumu) would be an ideal place to build a pilot spirulina farm. SmartFish could set up its own spirulina pilot production plant, or as an alternative "hire" one of the ponds from one of the current producers and pilot spirulina production.

The producer would benefit from this by receiving funding for the operational costs and part of the revenue from the spirulina sold.

Other areas where a pilot spirulina farm could be established are;

1. Uganda – Jinja, due to its high fish aquaculture activities.
2. Uganda – CESVI
3. Ethiopia (Lake Shala – South of Addis Ababa) spirulina exists in the lake and a sample should be taken and tested in labs for its purity and nutritional contents.
4. Northern Tanzania – Mwanza area
5. Lake Turkana - Kenya

5.3 Costs for a communication programme.

The communication budget could support initial costs for a training course in order to raise awareness, to be held in Kisumu at IIMSAM.

This would the SmartFish focal points to fly to Kisumu and attend the 2 day training session. The training would focus on production (IIMSAM) and marketing (Mr. Jagpal Sandhu).

Costs involve:

- Per Diem for Focal Points + flights to Kisumu + cost of the course for each participant (approximately Euro 120 for the 3 day course)
- Spirulina Marketing Consultant (1 day) – Jagpal Sandhu
- Paraphernalia – tee-shirts, caps etc. for the participants
- Media coverage for the event – Radio/TV etc.

ANNEX I – TERMS OF REFERENCE

AGROTEC CONSORTIUM 	
Assignment Name	Implementation of a Regional Fisheries Strategy (IRFS) for ESA-IO
Mission Schedule Number	STE-11 – 705012 / 424158
Coordinator	Chris Short, KE3; Coordinator of RESULT 4: Regional Trade Strategy
Technical Verifier	Chris Short, KE3; Coordinator of RESULT 4: Regional Trade Strategy
Background to assignment	The IRFS programme (SmartFish) was launched in February 2011 with the aim of contributing to an increased level of social, economic and environmental development and deeper regional integration in the ESA-IO region through the sustainable exploitation of fisheries resources. There are 19 beneficiary countries in the programme which is financed by the EU under the 10th EDF within a total financial contribution of Euro 21 million. The programme is implemented by the Indian Ocean Commission (IOC) in collaboration with the Common Market for East and Southern Africa (COMESA), the East Africa Community (EAC) and the Inter-Governmental Authority on Development (IGAD). Other regional institutions are also involved including SADC, IOTC, SWIOFC, LVFO, and LTA. The first phase of the programme will be implemented over a period of 31 months (End February 2011- September 2013). The overall objective of the programme is to contribute to an increased level of social, economic and environmental development and deeper regional integration in the ESA-IO region through the sustainable exploitation of fisheries resources. The expected results and outcome of the programme falls into the following five categories: fisheries governance; fisheries management; monitoring, control and surveillance; regional fish trade and food security. This assignment: under the mandate of the "communications on all result areas" (LOGFRAME 705012) provides support to Result 4 (regional fish trade component) of the project under activities related to developing diversification opportunities for artisanal fishers. In this area, we are interested to understand opportunities for DIVERSIFICATION and to COMMUNICATE AND PROMOTE such opportunities within the region, with a specific focus on the artisanal sector. Diversification (of an industry/ sector) is a strategic term that refers to new possibilities to expand options beyond existing capabilities and resources. It speaks to developing new markets (new customers) and new products (innovation). Market diversification at the regional and/or international level is of interest for this study from the perspective of individual countries as a focus but with regional relevance in terms of demonstrating possibilities throughout the region. Spirulina production is known to be underway in the region, but it is generally undeveloped and less understood that some of the more traditional aquaculture alternatives. The known nutritional and health benefits, as well as marketing opportunities for this high value product, indicate that it could be an interesting option in countries where the environmental conditions favour its growth. A study therefore is envisaged that will identify the potential in the ESA-IO region. An overview (pre-feasibility level) study for a small operation to produce Spirulina is of interest to the SmartFish programme with respect to potential for diversification of the artisanal fishing sector and enhancement of regional trade and food security. The assignment is to produce a document that may or may not stimulate further interest from the SmartFish programme and provide a "where are we – situation update" for Spirulina in the region. The ultimate objective of the assignment is to determine whether Spirulina production can be practically pursued at the artisanal level and if so where the SmartFish programme can then assist in piloting/ training, promoting and enhancing the potential in selected areas with the use of communication techniques designed for the appropriate audiences. With the specific objective of fitting such activities into

Issues to be addressed	The specific task is to: **Prepare an assessment of the present commercial Spirulina situation in the region and define the requirements for piloting and communication of the opportunities as a key diversification strategy for fisheries.** Expertise required: Spirulina production /market specialist
Activities of the Consultant	The expert shall prepare a document that includes, but is not necessarily restricted to, the following outline table of contents: 1. What is Spirulina? a. Information about the species involved, general description of its biology and geographical/environmental limitations, etc. b. What are the uses for Spirulina? / What relation does it have to fisheries/aquaculture? 2. Spirulina Operations in the ESA-IO region a. What's in place, what is planned, level of investment, etc. b. Where / Who? c. What is working and what isn't? 3. Product forms and Markets a. Types of products that are produced from Spirulina b. Overview of Regional markets for Spirulina products c. Overview of Export (ex-regional) markets for Spirulina products 4. Typical Small Scale investment requirements a. Operational requirements i. Technical inputs/design considerations (equipment, power, water, fuel, etc.) ii. Human resource requirements (including educational/technical level) iii. Other operational requirements iv. Requirements for marketing and distribution, cooperatives, buyers, connections to markets required and constraints around this issue v. What are the key risks to the success of the operation? b. Financials i. Approximate capital costs to start an operation ii. Approximate operating costs for a small scale, non-intensive operation that might be suitable for small scale investment iii. Potential revenue / profits from such an operation 5. Recommended next steps for a pilot project and communication of the merits for diversification in the fisheries sector a. Overall recommendations regarding Spirulina development in the ESA-IO b. If analysis is positive recommend 2 or 3 locations in the ESA-IO region where SmartFish might put effort into demonstrations, piloting and training for Spirulina production c. Define a the requirements and costs for a communication programme to promote and communicate diversification for selected communities into Spirulina production, as well as promote the health benefits of the products **Final Reporting** 1. Prepare a draft report and following comments received prepare the final report for the assignment
Expected outputs	The Expert shall produce a report demonstrating the work done, namely: a) Final Report The report to be produced using MS Word (and other MS Office software if necessary) and be available in hard copy and electronic form, both in Word (and other MS Office Programmes as appropriate) and all the elements together in single file pdf format.

Format of each report	- VARIOUS REPORT FORMATS TO BE AGREE WITH SUPERVISOR IN ADVANCE - Final Report to include: - MS Word Styles for IRFS Programme Reports and Technical Papers - Structure - Title pages in model format as per other Programme Reports – to be supplied - Table of contents, to three levels, formal format – to be agreed - List of annexes if appropriate - Tables of tables, figures and pictures all formal format - Abbreviations and acronyms - Layman's summary (one paragraph encapsulating key elements that can be used in magazine/web i.e. not over technical) - Executive Summary (1 to 2 pages), in English, and French - Introduction - Main body of report divided into different sections as appropriate, normally Context, Methodology, Performance in relation to TOR, and Discussion (up to 20 pages) - Conclusions and recommendations (each recommendation must be preceded by a conclusion, that refers to a discussion in the main body of the report) - Annex 1 Terms of reference (if appropriate) - Annex 2 Schedule and people met (with contacts) - Annex 3 Aide Memoire (max. one page on execution of mission, findings, conclusions, and recommendations in bullet points) - Any other annex(es) as appropriate - Format as per PMU indications.	
Report reviewed by	Chris Short, Key Expert for Trade Result	
Duration	SPIRULINA Specialist	Days
	(i) Desk Study, background research from home base	4
	(ii) Travel to field	1
	(iii) Field Mission to investigate markets and production examples, data collection, interviews with stakeholders, etc.	10
	(iv) Return to home base	1
	(v) Preparation and submission of draft report	4
	(vi) Final report preparation after comments from PMU/Stakeholders	1
	(viii)	
	(viiii)	
	(ix)	
	(x)	
	Total	21
	Total input days: 21 working days	
Start date	Approximate: Start November/ December 2011	
Completion dates for Reports and fee payment schedule	Draft report Comments from PCM Final report	Whilst on Mission, and following mission Within 1 week after submission of draft report Before End December 2011
	Final report basis for relevant payments	

Experience and qualification	Qualifications and skills: - fluency in one of French or English and working knowledge of other - Implementation of Communication plans - Demonstrated experience with Spirulina or other algae production and markets and relevant access to information - Experience working with EU projects an advantage - Ability to travel and work in ACP countries
Locations and travel	Home base + travel in region as required: Travel from: (Home base) >>Regional countries>>to (Home base)
Requested: Project Team Leader Date:	
Validated: Programme Manager, for IOC-RAO Date:	

ANNEX II – PEOPLE MET DURING THE MISSION

Name	Agency	Telephone #	E-mail address
Jagpal Sandhu	Dunga Spirulina	+254 722 747040	JAGPALSANDHU@HOTMAIL.COM
Dr. Ojwamg	KMFRI - Kisumu	=254 720 206495	W_OJWANG@YAHOO.COM
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Dr. David Tigawalana	Uganda Aids Commission	+256 772 400248	
Mr. Robert Ochai	TASO	+256 751 774774	
Dr. Joshua Musingusi	Ministry of Health Programme Manager	+256 772 611135	

ANNEX III - ESTIMATED COSTS OF A PILOT SPIRULINA FARM

Estimated costs of starting a 500 sq. m pilot spirulina farm
(All costs in Euros)

Land Area required about a quarter of an acre or 900 sq m (30m X 30m)

Price per acre -	8000
Number of acres	1/4
Total price of land	2,000.00
Legal and transfer costs 10%	1,000.00
Biulding costs	
Boundry wall	
8 ft high - cost per meter 50.00 X 60	3,000.00
Landscaping	1,000.00
Security lighting	500.00
Independent production units	
500 mt.sq raceway pond (6m W X 80m L X 1m H)	10,000.00
Galvanised super structure for covers	1,000.00
UV. Proof covers	500.00
1000w geared motor	200.00
Paddle wheel and fittings	650.00
Pumps and piping	350.00
Harvesting station	200.00
Drying Screens (each)	100.00
Solar Dryer	500.00
Total independent production units	13,500.00
Shared Structures	
Fresh Water Treatment pond	1,000.00
Small and Medium culture ponds	2,000.00
Testing and monitoring laboratory	10,000.00
Administrative building	10,000.00
Storage / Packaging Unit / Grinding	5,000.00
Washrooms	6,000.00
Guard Unit	2,000.00
PV (Photovoltaic) Solar Power Unit	3,000.00
Total Shared Structures	39,000.00
Total Setup cost:	60,000.00
Operational costs	
Culture cost	100.00

Per pond inoculation costs:	
Water 100 m3 x 3.5	150.00
Medium preparation fertilizer	200.00
Total for 1 ponds	350.00
Monthly Operational costs	
Labour	
Farm Manager	200
Lab Operator	150
Packing Manager	120
Unit staff 2 per unit (100 x2 x 1)	200
Gardner / groundskeeper	100
Guard	150
Total Labour costs p/m	920.00
Total Operation costs per month	1,370.00
Production costs	
Total expected output - 10g/sq.mt/day	
500 sq.mt = 5 kg per day	
Wholesale price per kg - 50	
Total expected production x wholesale price/ day	250
Direct cost - water/ fertilizer / day	50
Gross Profit / day	200
GP per month (average 25 days)	5,000.00
Less Monthly Expenses	1,370.00
Total Expected Net profit per month	3,630.00

ANNEX IV - TECHNICAL SPECIFICATIONS OF WELL AT IIMSAM

KAJULU DRILLING CONTRACTORS LIMITED 29 February 2012
CONTRACT: DRILLING OF 1 NO. BOREHOLE AND RELATED WORKS.
PART 1 of 6: HYDROGEOLOGICAL SURVEY

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	Mobilization & Demobilization to Site	LS	1	5,000	5,000
2	Hydrogeological/Physical Survey	LS	1	29,000	29,000
3	Reports on the Survey	NO	3	2,000	6,000
	Total				**40,000**

PART 2 of 6 : DRILLING

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	Mobilization, demobilization of whole drilling plant and personnel, stores and other materials	Ls	1	55,000	55,000
2	Setting and dismantling of drilling unit and camp	Ls	1	25,000	25,000
3	Supply water and drilling foam for drilling	Ls	1	7,000	7,000
4	Supply and installation of 8" diam. (external) plain temporary steel casing from surface	m	1	8,500	Rate only
5	Drilling of the borehole with final cased diameter of 6" diam. To the required depth as indicated below;				
	a) Open hole diameter of 8" for installation of surface casing	m	6	3,300	Rate only
	b)Open hole diam 8"(0-100m)	m	100	4,800	480,000
	b)Open hole diam 8"(100-200m)	m	20	5,200	104,000
6	Formation samples collection at 2m intervals	No.	60	150	9,000
7	Physical logging of collected lithological samples	No.	60	150	9,000
8(i)	Supply & installation of plain casings 152 mm (6") internal dia.(upvc)	m	84	2,000	168,000
(ii)	Supply & installation of slotted casings 152 mm (6") internal dia.(screens)(upvc)	m	36	2,300	82,800
(iii)	Supply & installation of plain casings 152 mm (6") internal dia.(steel)	m	84	3,210	Rate Only
(iv)	Supply & installation of slotted casings 152 mm (6") internal dia.(steel)	m	36	3,490	Rate Only
9	Supply and installation of end cap	No.	1	4,000	4,000
10	Supply and installation of gravel pack filter material (2-4mm average diam. Size)	Ton	8	3,500	28,000
11	Backfilling inert material in the annulus	M3	1	2,500	2,500
12	Supply of grouting material and installation	M3	2	1,500	3,000
13	Development & cleaning the borehole by air lift pumping(or until water is clean) by compressor	Hrs	4	5,000	20,000
14	Test pumping works				

15.1	Collect drawdown data & measure discharge(m3/hr) in the following operations;				
	a) Installation and removal of test pumping plant	Ls	1	15,000	15,000
	b)Trial Test Pumping: Calibration and step draw down test	Hrs	4	200	800
16	Construction of well head and concrete plinth 1.0m *1.0m*0.5m thick including capping of well	Ls	1	3,000	3,000
17	Water analysis-chemical/Supervision	Ls	1	2,000	2,000
18	Borehole completion report and test records	Ls	1	1,900	1,900
	Sub Total				
	Total				**1,020,000**

PART 3 of 6: SUPPLY AND INSTALLATION OF BOREHOLE PUMP(SUBMERSIBLE)

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	Grundfos Sp 5A-12 1.1KW 1PH Duty: 5M3/Hr at 70m,115 Max Head	No	1	100,000	100,000
2	2.5mm3 3Core Submersible Cable (M)	Mts	48	300	14,400
3	Dayliff 3M Pipes 1½"	Mts	16	1,440	23,040
4	Dayliff Starter Pipe 1½"	No	1	700	700
5	Datliff Adaptor Set 1½"	No	1	2,160	2,160
6	Airline	No	8	250	2,000
7	Borehole Cover 1½" x 6"	No	1	18,900	18,900
8	Londex Cable	No	96	50	4,800
9	Electrodes	No	2	1,870	3,740
10	Dayliff Control Panel 1.1KW 1PH	No	1	50,400	50,400
11	2.5MM^2 3Core U/G Cable	Mts	10	500	5,000
12	Installation Sundries	Ls	1	18,000	18,000
13	Labour and Transport	Ls	1	38,000	38,000
	Total				**281,140**

PART 4 of 6: CONSTRUCTION OF BUILTIN PUMP HOUSE AND TANK TOWER.

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	**EXCAVATION** To excavate 2m deep 2.5 x 2.5 m for column foundation.	Cm	15	800	12,000
2	**CONCRETE WORK**				
	1.25mm thick vibrated concrete in foundation slab.	Sm	4	6,000	24,000
	200mm thick hard core filling well compacted in 100mm layers	Sm	12	2,000	24,000
	50mm thick murram blinding	Sm	12	1,100	13,200
	400mm x 200mm vibrated reinforced concrete in columns	Cm	4	7,000	28,000
	250mm thick vibrated reinforced concrete in slab.	Sm	4	5,000	20,000
	100mm x 100mm x 200mm thick column bases	Cm	1	4,000	4,000
	Water	Ls	1	5,000	5,000
	Sub Total				**118,200**
3	**REINFORCEMENTS**				
	Bases Y12	Pcs	35	1300	45,500
	Bottom Slab Y10	Pcs	30	1,100	33,000
	Top Slab Y12	Pcs	22	1,200	26,400
	Columns Y16	Pcs	24	1,400	33,600
	Beams Y16	Pcs	15	1,400	21,000
	Mild Steel R8	Pcs	45	400	18,000
	Binding Wire	Kg	10	200	2,000
	Sub Total				**179,500**
4	**FORM WORK**				
	200mm x 250mm to sides and soffits of top and bottom Slab	Lm	250	200	50,000
	200mm x 25mm to sides of columns	Lm	40	180	7,200
	Round Poles	No	80	120	9,600
	Wire Nails	Kg	20	100	2,000
	100mm x 50mm to bottom of soffits & Slabs	Lm	60	70	4,200
	100mm x 50mm to sides of columns RHS 50mm x 25mm for guard	Lm	60	70	4,200
	rails and ladder	Pcs	10	600	6,000
	Sub Total				**83,200**

5	BUILT IN PUMP HOUSE				
	200mm x 150mm x 100mm bricks	No	800	90	72000
	Grilled Steel Door	No	1	8000	8000
	Cement	Bag	15	900	13500
	Sand	Ton	10	900	9000
	Sub Total				١٠٢,٥٠٠
	SUMMARY				
1	EXCAVATION				12,000
2	CONCRETE WORKS				118,200
3	REINFORCEMENTS				179,500
4	FORMWORK				83,200
5	BUILT IN PUMP HOUSE				102,500
6	LABOUR	Ls	1	80,000	80,000
7	TRANSPORT	Ls	1	5,000	5,000
	Sub Total				580,400
	Total				**580,400**

PART 5 of 6: PLUMBING WORKS

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	PVC Pipe 1½"	No	18	850	15,300
2	PVC Pipe 1¼"	No	9	750	6,750
3	PVC Pipe 1"	No	8	400	3,200
4	GI Pipes 1½"	No	4	3,300	13,200
5	GI Pipe 1"	No	2	2,500	5,000
6	GI Pipe 3/4"	No	1	1,700	1,700
7	Gate Valve Peggler 2"	No	1	4,500	4,500
8	Gate Valve Peggler 1½"	No	2	3,500	7,000
9	Lockable Taps 3/4"	No	3	1,200	3,600
10	Barrel Nipple 2"	No	2	400	800
11	Barrel Nipple 1½"	No	2	350	700
12	GI Elbow 1½"	No	5	150	750
13	GI Elbow 1"	No	5	70	350
14	GI Elbow 3/4"	No	5	40	200
15	GI Tee 1½"	No	3	250	750
16	GI Tee 1"	No	2	100	200
17	GI Tee 3/4"	No	2	40	80
18	Gi Nipples 1½"	No	4	150	600
19	GI Nipples 1"	No	2	120	240
20	GI Nipples 3/4"	No	3	40	120
21	GI Union 1½"	No	3	250	750
22	GI Union 1"	No	3	150	450
23	GI Union 3/4"	No	3	90	270
26	GI R/Bush 1½" x 1¼"	No	3	250	750
27	GI R/Bush 1¼" x 1"	No	3	150	450
28	PVC Adaptors 1½"	No	8	200	1,600
29	PVC Elbows 1½"	No	5	150	750
30	PVC Elbows 1¼"	No	3	150	450
31	Boss White	No	3	250	750
32	Solfix	No	4	900	3,600
33	Hemrope	Ft	5	50	250
	Materials				75,110
	Excavation	Ls	1	15000	15,000
	Labour				22,533
	Total				**112,643**

PART 6 of 6: ELECTRICAL INSTALLATION

ITEM	DESCRIPTION	UNIT	QTY	RATE	RATE AMOUNT (KES)
1	2.5mm Armoure Cable 3c	Mts	20	1,200	24,000
2	Switch fuse 32A	No	1	5,500	5,500
3	Spliter 2 Ways 30A	No	1	900	900
4	S/sockets 13A metal	No	1	700	700
5	Floresent fitting T & J	Ft	1	1,800	1,800
6	Bulk Head fitting	No	1	800	800
7	P.V.C 25mm H/g Conduits	No	2	450	900
8	P.V.C 20mm H/g Conduits	No	3	90	270
9	P.V.C 25mm H/g Copplings	No	10	35	350
10	P.V.C 38mm H/g Conduits	No	10	30	300
11	P.V.C 20mm H/g Copplings	No	2	350	700
12	1.5mm Twin with earth Cable	Mts	30	100	3,000
13	Looping in Box	No	1	1,500	1,500
14	Earth Wirelead 6.0mm	Mts	1	400	**400**
15	Earth rode 4ft	Pc	6	100	600
16	Metal Stand board 30" x 30 with bushesmale & female	No	1	1,500	1,500
17	2 Gauge Switch	No	1	1,200	1,200
18	Asbestoes 2.5mm 3C	Mts	7	450	3,150
19	Trenching Cable laying and back	Mts	1	7,500	7,500
20	Saddle 20mm	No	6	250	1,500
21	3 Way box 20mm	No	3	300	900
22	Wood Screw	Pc	1	300	300
23	MK Box	No	1	500	500
24	Single Cut Out	No	2	700	1,400
25	Twin Cut Out Material Cost	No	1	2,500	2,500 62,170
26	Transport	Ls	1	9,000	9,000
27	Labour	Ls	1	9,000	9,000
	Total				**80,170**

SUMMARY OF QUOTATION

ITEM	DESCRIPTION	RATE AMOUNT (KES)
1	SURVEY & REPORTS	40,000
2	DRILLING WORKS	1,020,000
3	SUPPLY AND INSTALLATION OF SUBMERSIBLE PUMP	281,140
4	CONSTRUCTION OF 6M TANK TOWER & BUILTIN	580,400
	PUMP HOUSE	
5	PLUMBING WORKS	112,643
6	ELECTRICAL INSTALLATIONS(PUMP HOUSE)	80,170
	TOTAL (KENYAN SHILLINGS)	2,114,353

Approximately - Euros 20,000
Exchange rate: EURO 1 = KES 105

LIST OF PUBLICATIONS – LISTE DES PUBLICATIONS

SmartFish Programme

1. *Report of the Inception / Focal Point Meeting of the SmartFish Programme – Flic en Flac, Mauritius, 15th-16th June 2011*. REPORT/RAPPORT: SF/2011/01. August/Août 2011. SmartFish Programme. Indian Ocean Commission (55 pages).

2. *Report of the First Steering Committee Meeting of the SmartFish Programme – Flic en Flac, Mauritius, 17th June 2011*. REPORT/RAPPORT: SF/2011/02. August/Août 2011. SmartFish Programme Indian Ocean Commission (51 pages).

3. *Rapport de la réunion de présentation du programme SmartFish aux points focaux – Flic en Flac, Ile Maurice, 15-16 juin 2011*. REPORT/RAPPORT: SF/2011/03. August/Août 2011. SmartFish Programme. Indian Ocean Commission (55 pages).

4. *Eco-Certification for the Tuna Industry, Technical Assistance for Implementation of a Regional Fisheries Strategy for ESA-IO (IRFS)*. REPORT/RAPPORT: SF/2011/04. May 2011. SmartFish Programme. Indian Ocean Commission (40 pages).

5. *Regional Market Assessment (Supply and Demand)*. REPORT/RAPPORT: SF/2012/05. March/Mars 2012. SmartFish Programme. Indian Ocean Commission (264 pages).

6. *Trade Assessment Study*. REPORT/RAPPORT: SF/2012/06. March/Mars 2012. SmartFish Programme. Indian Ocean Commission (120 pages).

7. *Gouvernance des Pêches Maritimes dans l'Ouest de l'Océan Indien*. REPORT/RAPPORT: SF/2012/07. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (101 pages).

8. *Value Chain Assessment of the Artisanal Fisheries – Mauriti*us. REPORT/RAPPORT: SF/2012/08. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (85 pages).

9. *Kenya Fisheries Governance*. REPORT/RAPPORT: SF/2012/09. June/Juin 2012. SmartFish Programme. Indian Ocean Commission (36 pages).

10. *Training Needs Analysis – Quality and Hygiene*: REPORT/RAPPORT: SF/2012/10. June/Juin 2012.SmartFish Programme. Indian Ocean Commission (95 pages).

11. *A Review of Somalia's & (Semi-Autonomous Regions) Fisheries Legislation and Managemen*t. REPORT RAPPORT: SF/2012/11. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (49).

12. *Assessment of IUU Activities On Lake Victoria*. REPORT/RAPPORT: SF/2012/12. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (130 pages).

13. *Review Of The Legal Framework for the ESA-IO Region*. REPORT/RAPPORT: SF/2012/13. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (149 pages).

14. *Comprehensive capacity review to implement effective MCS in the ESA-IO Region*. REPORT/RAPPORT: SF/2012/14. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (101 pages).

15. *Assessment of IUU Fishing in Lake Tanganyika*. REPORT/RAPPORT: SF/2012/15. June/Juin 2012 SmartFish Programme. Indian Ocean Commission (52 pages).

16. *Spirulina – A Livelihood and a Business Venture*. REPORT/RAPPORT: SF/2012/16. SmartFish Programme. June/Juin 2012 Indian Ocean Commission (43 pages).

La bonne gouvernance et de la gestion des pêches et de l'aquaculture permettent d'améliorer la contribution du secteur à la sécurité alimentaire, au développement social, à la croissance économique et au commerce régional ; ceci en assurant par ailleurs une protection renforcée des ressources halieutiques et de leurs écosystèmes.

La Commission de l'Océan Indien (COI) ainsi que la COMESA (Common Market for Eastern and Southern Africa), l'EAC (East African Community) et l'IGAD (Inter-Governmental Authority on Development) ont développé des stratégies à cette fin et se sont engagés à promouvoir la pêche et l'aquaculture responsable.

SmartFish supporte la mise en œuvre de ces stratégies régionales en mettant l'accent sur le renforcement des capacités et des interventions connexes visant à :

- mettre en place des mécanismes pour la gestion et le développement durable des pêches ;
- développer un cadre de gouvernance des pêches au niveau régional ;
- renforcer le suivi-contrôle-surveillance pour les pêcheries partagées ;
- développer des stratégies et supporter des initiatives propres à accroître le commerce régional du poisson ;
- contribuer à la sécurité alimentaire en particulier par la réduction des pertes après captures et la diversification de la production.

SmartFish est financé par l'Union Européenne dans le cadre du 10ème Fond Européen de Développement.

SmartFish est mis en œuvre par la COI en partenariat avec la COMESA, l'EAC et l'IGAD et en collaboration avec la SADC. Une collaboration étroite a également été développée avec les organisations régionales de pêche de la région. L'assistance technique est fournie par la FAO et le consortium Agrotec SpA.

By improving the governance and management of our fisheries and aquaculture development, we can also improve food security, social benefits, regional trade and increase economic growth, while also ensuring that we protect our fisheries resources and their ecosystems.

The Indian Ocean Commission (IOC), the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC) and the Inter-Governmental Authority on Development (IGAD) have developed strategies to that effect and committed to regional approaches to the promotion of responsible fisheries and aquaculture.

SmartFish is supporting the implementation of these regional fisheries strategies, through capacity building and related interventions aimed specifically at:

- implementing sustainable regional fisheries management and development;
- initiating a governance framework for sustainable regional fisheries;
- developing effective monitoring, control and surveillance for transboundary fisheries resources;
- developing regional trade strategies and implementing regional trade initiatives;
- contributing to food security through the reduction of post harvest losses and diversification.

SmartFish is financed by the European Union under the 10th European Development Fund.

SmartFish is implemented by the IOC in partnership with the COMESA, EAC, and IGAD and in collaboration with SADC. An effective collaboration with all relevant regional fisheries organisations has also been established. Technical support is provided by Food and Agriculture Organization (FAO) and the Agrotec SpA consortium.

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