WORKSHOP REPORT

Report of the FAO Expert Workshop on "Use of feeds and fertilizers for sustainable aquaculture development"

WUXI, JIANGSU PROVINCE, PEOPLE'S REPUBLIC OF CHINA, 18–21 MARCH 2006

ORGANIZED IN COLLABORATION WITH THE FRESHWATER FISHERIES RESEARCH CENTRE, WUXI, CHINA AND THE NETWORK OF AQUACULTURE CENTRES IN ASIA-PACIFIC (NACA)

THE WORKSHOP

The Aquaculture Management and Conservation Service (FIMA) of FAO organized an expert workshop on the "Use of feed and fertilizer for sustainable aquaculture development" in Wuxi, Jiangsu Province, People's Republic of China, on 18–21 March 2006 in collaboration with the Freshwater Fisheries Research Centre (FFRC) of China and the Network of Aquaculture Centres in Asia-Pacific (NACA). The workshop was hosted by Freshwater Fisheries Centre (FFRC), Chinese Academy of Science at the FFRC Campus in Wuxi, Jiangsu Province, China. The workshop was undertaken as a part of FIMA's work programme entitled "Study and analysis of feed and nutrients (including fertilizers) for sustainable aquaculture development" under the programme entity "Monitoring, Management and Conservation of Resources for Aquaculture Development".

OBJECTIVES AND OUTPUTS OF THE WORKSHOP

The principal objective of the workshop was to review and analyse the current status and trends in aquaculture production and to identify key issues and challenges of feed and fertilizer resource use for sustainable aquaculture development. Several key issues were identified and prioritized during the technical and working group sessions and appropriate actions were recommended.

The anticipated outputs were to publish the proceedings of the workshop and to provide recommendations to the Third Session of the COFI Sub-committee on Aquaculture (SCA) that was held in New Delhi, India, September 2006. The identified key issues and recommendations made to the third session of COFI-SCA (i.e., policy guidelines, research, capacity building, extension and application) are expected to enable policy makers on a global and regional level to implement improved aquaculture

practices and farming systems through optimal use of feeds and fertilizers resources and to assist FAO member countries in the implementation and promotion of the provisions of the Code of Conduct for Responsible Fisheries (CCRF Article 9.4.3[1]).

PARTICIPANTS

The workshop was attended by a wide range of research and development and industrial experts in aquaculture nutrition from around the globe (Annex V).

OPENING OF THE WORKSHOP

The participants were welcomed by Prof Xu Pao, Director, Freshwater Fisheries Research Center (FFRC), Chinese Academy of Fishery Sciences and the workshop was opened by Mr Li Jieren, Vice President of the Chinese Academy of Fishery Sciences.

FORMAT OF THE WORKSHOP

The workshop included technical presentations and working group discussions. The technical presentations were intended to orient the participants to the inter-regional commonalities, differences and problem issues pertaining to the use of feeds and fertilizers in aquaculture. The technical presentations included:

- Country Reviews: Study and analysis of feeds and fertilizers for sustainable aquaculture development
  - China, India, the Philippines, Thailand, Viet Nam, Egypt and Uganda
- Country Reviews: Development of aquafeed industries
  - China, India and Egypt
- Regional Syntheses
  - Feeds and sustainability of Asian aquaculture
  - Developments in sub-Saharan African aquaculture: feeds and fertilisers
  - Aquaculture feeds in Latin America: a look at key elements at the macro (the industry) and micro (farm practices) levels
- Presentation of case studies on economics of aquaculture feeding practices
  - Case study on the use of farm-made feeds versus commercially-formulated pellets for pangasiid catfish in the Mekong delta, Viet Nam
  - The economics of small-scale aquaculture feeding systems in China
  - An economic analysis of aquaculture feeding systems: a synthesis of three Asian countries
- Invited presentation
  - Reducing waste production of aquaculture by improvement of feed formulation and feeding regime
- Global Synthesis
  - Feeds and nutrients for sustainable aquaculture development within developing countries: a global synthesis

Participants were then divided into two working groups and tasked to examine one or more thematic area(s) on feed and fertilizer use in aquaculture, to identify critical issues and to suggest specific actions and make recommendations to address these issues (the working group procedure is detailed in Annex IV). The working group recommendations were presented to the plenary for approval.

[3] CCRF Article 9.4.3: States should promote efforts which improve selection and use of appropriate feeds, feed additives and fertilizers, including manures.

SUMMARY OF WORKING GROUP OUTPUTS: IDENTIFICATION OF KEY ISSUES AND RECOMMENDATIONS

WORKING GROUP A THEME: Industrial aquafeed- development of the industry, impact of availability of protein sources, alternatives and their feasibility

The working group recognized that commercial feed production was generally driven by market forces and this has a strong influence on the decisions made by aquafeed producers. However, there are a number of areas where external forces have an influence on the feed sector or where the feed sector relies on external support/advice or resources. The group also affirmed that the real price of fish was not increasing. This means that feed utilization must become more efficient and, wherever possible, cheaper feeds will have to be produced. The working group identified five areas that require attention and remediation to ensure the sustainable development of the sector. These are:

- Policy and regulation
- Ensuring that research is effectively connected to commercial reality
- Capacity building and management, particularly at farm level
- Fish-based ingredients and alternatives
- Availability and sourcing of ingredients

1. Policy and regulation

Legislating on feeds may not be an effective way to regulate resource use as overly high restrictions can increase the price of feed to a point where farmers may have difficulty in making a profit. There are three levels at which it is possible to influence the sector.

- Government legislation regarding allowable environmental impacts and food safety requirements of the product
- The market determines the demand and price of the product and this influences the activity and decisions of the farmer.
- Greater awareness of farmers regarding optimal production methods and management

1.1 Setting national feed standards

In several countries, national standards have been set for the nutrient content of feeds for a number of species. However, this does not deal adequately with the diversity of production systems. While it is relatively easy to define standards for cold, clear water systems it is more complex in warm, greenwater systems in which the fish obtain considerable supplemental feeding.

The setting of standards for feeds that have overly high nutrient levels (such that they reflect the complete requirement of the animal) may actually encourage inefficient resource use and also limits the ability to capture the benefit of supplementary nutrition in the pond/production environment.

Any standards should reflect the reality of farming systems and the natural variability that exists between these systems. National standards can be misleading since they may be benchmarked against fishmeal based feeds. Standards should be more flexible to indicate a range (protein, CHO, energy etc.) for different farming systems rather than an absolute figure based on the nutritional requirements of species. Hence, there is a need to review national standards and develop realistic guidelines or advisory material regarding the likely needs for different systems and species. This should be used to inform national aquafeed legislation

1.2 Lack of quality standards for raw materials

There is a need to review nutrient specifications of raw materials and to set classification standards for raw materials (i.e. a classification system Class A, Class B etc.), that could then be used for different feeds and culture systems. This would greatly assist feed manufacturers.

Example

Different types of lecithin quality in China

1.3 Review existing mechanisms of incentives and subsidies in the animal feed sector

The range of incentives and subsidies are vast and could not be dealt with in the allotted time. Nevertheless it was recognised that incentives can play an important role in enabling or constraining parts of the aquaculture sector and which may preferentially favour export orientated aquaculture over smaller scale domestic activities.

Examples

- Reduced duty on feed and or raw material imports or duty free imports
- Tax exemptions on feeds for products destined for export
- Feeds classified as 'foodstuffs' may be subject to high tariffs
- Import substitution should be eligible for reduced duties
- Zero tax on major feed ingredients
- High import tariffs on feed additives/pre-mix (leads to smuggling and associated problems with regard to labelling and inclusion of banned substances)
- Government incentives for R&D leading to a reduction in inclusion levels of critical raw materials or their replacement

1.4 Impose levies on feeds and direct the proceeds into research and development

While the direct benefits of a levy are clear and very sensible, this is typically unpopular with the industry since the cost of the levy is inevitably transferred to the farmer. The imposition of feed levies to fund R&D requires clear demonstration that the public sector will use the research funds appropriately and that the research will be useful for all sectors of the industry. In addition there would have to be a strong partnership between research and the industry to set research priorities. Such a fund could also be used for training to improve feed utilization at the farm level.

1.5 Provision of affordable credit to break the barrier for extensive farmer to go into semi-intensive operations

This is of particular importance in Africa but examples from other regions also exist. There is a strong need to inform financial institutions of the economic benefits of aquaculture, the need to feed fish and its impact on the ability to repay a loan

Example

- In Africa, lack of land tenure prevents the use of land as collateral and constrains borrowing.
- Philippines – government bank provides loans to small producers wanting to move to semi-intensive operations, but they have to from fishery cooperatives to access (no collateral) loans.

1.6 Environmental regulations to be developed to limit impacts of aquaculture

Feed mills need to improve feed quality to reduce leaching of nutrients and to improve digestibility of the feeds.

Example
- China is considering a ban on the use of trash fish in the near future
- China is also considering discharge regulations

2. Ensuring that research is effectively connected to commercial reality

Laboratory based feed research relies on controlled conditions. In most instances laboratory trials cannot continue until the fish has reached market size and thus may have limited application to commercial culture conditions. Many feed companies undertake their own research under commercial farming conditions to fully test their feeds; however this information is often proprietary and is not generally available.

There is a need to partner public funded research with the commercial feed manufacturing sector. This will provide a better understanding of reality. It will also allow the setting of better standards and will allow research results to be more effectively transferred to farmers.

Example

Clearwater nutrition trials on tilapia nutrition do not allow for the contribution of phytoplankton to nutrition. If tilapia are well fed they will not use the phytoplankton as a supplement, thus a balance in the diet and feeding regime needs to be reached to optimize the systems.

2.1 Increase dialogue between the feed industry, academia and farmers and encourage cooperative research

It is of critical importance that industry and research organizations are effectively linked. In many countries research is often solely focussed on high value species and export oriented production/producers. Governments have an obligation to ensure that attention is also paid to the domestic sector and lower value crops.

Example
- China - feed industry has regular meetings with academics and fish farmers.
- Strong dialogue between Norwegian salmon farms and government with respect to management and research
- Brazil shrimp farmers association – development of industry GMP's, biosecurity protocols of disease emergence and water quality standards and consistent ingredient labelling
- Thailand – farmers association (annual meeting between farmers and scientists)

2.2 Determine proper feeding regimes and develop aquafeeds for specific culture systems

Feeding regimes should reflect the purpose and goal of the producer. Feeds for herbivorous/omnivorous species may not adequately incorporate the contribution of nutrition from the pond environment.

Example

Export quality tilapia may require that complete feeds and clearwater systems are used, whereas a domestic market may produce fish in greenwater systems with a cheaper feed to reduce production costs.

2.3 A general lack of baseline information on the nutrient requirements of most species in developing countries

There is a real need to assess and better understand the nutritional requirements of fish in marine as well as freshwater, greenwater / heterotrophic systems over and above that which they obtain from supplemental pond nutrients. Of critical importance for the

farmer is that this type of research be conducted on a commercial scale, over the entire production cycle, and that it incorporates an economic analysis.

3. Capacity building and management

3.1 Capacity building at farmer level

It must be recognized that the majority of aquafarmers operate at the household level and have relatively limited education. This means that the transfer of complex technical messages is problematic and requires continuous attention

3.2 Facilitate establishment of fish farmer associations to exchange information and facilitate education

This often enables farmers to access information more effectively.

3.3 Clustering of fish farms (small farms) to reduce risk

Large operations have a higher degree of control over inputs. However, smaller operations lack critical mass to exercise any degree of control over input costs and this increases risk. Risk can be reduced if farms are clustered or if farmers organize themselves into groups.

3.4 Training and extension services for small scale farmers must be enhanced

Government support for farmer training is inclined to favour those producing high value or export commodities. There is a need for better extension into domestic systems. Farmers associations can access information easier than individual farmer and can also train their members.

3.5 Capacity building results in significant increases in feed utilization efficiency

There is a need to disseminate information to farmers on more efficient farm management practises and efficient use of feeds (e.g., monitoring, feed trays etc.). The industry is developing rapidly and farmers must keep pace with new technologies and developments, which otherwise will lead to greater inefficiencies.

4. Fish-based ingredients and alternatives

4.1 Fishmeal replacement

Fishmeal can be replaced to a large extent but at a cost (e.g. enzyme and amino acid supplementation), which brings the final cost of alternative feeds in line with fishmeal based diets. At this stage fishmeal is still relatively available and practices will continue until such time as the availability of fishmeal becomes seriously constrained.

4.2 Alternatives for fishmeal and fish oil

There is a pressing need to look at the use of unconventional feed ingredients, but there is limited knowledge or information on possible alternatives and their availability. Fish oil is considered to be a serious limiting factor; however there are alternatives that have not been fully explored. There is a need to look more closely at these alternatives and address the issues that relate to the constraints to their use (e.g. anti-nutritional factors).

4.3 Encouraging the move away from the use of trash fish

There is increasing consumer pressure for aquaculture to become more responsible and for the sector to use more sustainable resources as fish feed.

Example

China has taken note of the pressure and is considering a ban on trash fish use in the future. Moreover, the use of trash fish in the pangasid catfish industry raises potential future problems with respect to water quality and disease.

4.4 Research on fishmeal and fish oil replacements

Research is ongoing but the findings have not been translated into commercial practice.

Production and use of silage and/or fish hydrolysates using low value/trash fish or fish processing wastes

Fish silage and hydrolysates can substitute fishmeal to a certain extent and also act as effective attractants. These products are available but because they are wet it raises problems for large scale feed manufacturers. The technology for the manufacture of silage and hydrolysates is available but not yet transferred and/or the products are still expensive. These commodities provide options and opportunities for farm-made feeds and or small scale producers of moist feeds.

Improve fishmeal quality

There is a need for a greater degree of engagement with local fishmeal producing plants to improve the quality of their product or production efficiency. The down side of improving fishmeal quality is that the price will increase, which may have serious financial repercussions for small scale farmers.

Reducing the dependence on fishmeal imports

It was generally agreed that there has not been much focus on alternatives since fishmeal up to now has been readily available. However, the situation is changing and countries need to consider ways and means to reduce the dependence on imported fishmeal. India has largely succeeded in this endeavour, despite the fact that the local fishmeal is not of the same quality as that which is imported.

Examples

- Some countries regulate import of feedstuffs to protect the national market
- Classification of ingredients as feed grade/food grade
- Specific tariffs on additives
- Rising fishmeal prices does not seriously impact on the economics of farms that produce high value products. However, rising process seriously affects the profitability of lower value species farms.
- Governments can and should play an active role in encouraging the industry to change to local products
- Single cell proteins as fishmeal replacements are still too costly

5. Availability and sourcing of ingredients

5.1 Abuse of feed additives in aquafeeds - the need for regulation

Traceability issues remain an issue with regard to the composition of some feed additives. The composition of many additives is unknown and therefore raises the risk of the inclusion of banned or restricted chemicals. Several recent trade disputes in this regard have led some countries to introduce stringent control measures.

Feed millers are increasingly testing their raw materials to ensure that they are not a source of restricted chemicals (i.e. through contaminated feed ingredients). However in some countries restricted or banned chemicals/drugs are still available and are readily used.

5.2 Sourcing from sustainable feed supplies

There is a growing trend in demand for the use of feed ingredients from more sustainable sources. An emerging opportunity is the use of bone and animal by-product meals which were originally used in livestock feeds. Due to cross contamination concerns these commodities are no longer used by the animal feed industry and may provide an ideal alternative to fishmeal. The availability of these commodities is potentially vast.

5.3 Competition for raw materials with other sectors

Competition with the livestock sector and in some cases with direct human consumption for commodities used in aquafeeds is increasing (e.g. maize, soybean, reduction fisheries, wheat). While it is recognised that there is a difference between food grade and feed grade materials there will be increasing pressure in the future on the use of food grade materials in animal feeds. Moreover, there will be increasing competition for agricultural land for growing human food rather than growing crops intended for animal feeds.

5.4 GMO ingredients

The working group recognized that the use of genetically modified aquafeed commodities is and may become more problematic in future.

WORKING GROUP B THEME: Farm-made aquafeeds (including manures and fertilizers) -opportunities and constraints, availability, feasibility and management

The use of farm-made feeds and fertilizers plays very significant roles in aquaculture production in developing countries. However, it has received inadequate attention hitherto. Recognizing its importance, there is an urgent need to address issues related to farm-made feeds and fertilizers to ensure increased production efficiency and sustainable development of the aquaculture sector. The factors identified that are thought to be of immediate relevance can be categorized under five headings.

These are:

- Policy/guidelines
- Research and development needs
- Extension, application and adoption
- Capacity building; and
- Public and private sector partnerships.

1. Policy/Guidelines

Governments are encouraged to develop and implement appropriate policies with respect to farm-made feeds and fertilizers are developed and effectively implemented. Such possible policies should encompass the following factors and issues:

- use of farm-made feeds and fertilizers should ensure environmental integrity such as the prudent use of trash fish in farm-made feeds and integrating animal husbandry with fish culture;
- encourage the use of locally available raw materials and ingredients;
- in certain regions where use of farm-made feeds is non-existent, encouragement should be given to make use of locally available ingredients to promote the development of aquaculture;
- set quality and safety guidelines for effective use of farm-made feeds and fertilizers;
- provide support for needs based research;
- provide support for the procurement of suitable/appropriate equipment for farm-made feed and fertilizers;
- governments will have to recognize the possible negative impacts/influence of vested interests in the development of the farm-made feed and fertilizer sectors; and
- develop mechanisms for interregional and international cooperation on the use of farm-made feeds.

2. Research and development needs

Recognizing the importance of farm-made feeds and fertilizers in developing countries, there is a need to intensify research and dissemination of outcomes on the following aspects:

- collate and update information on ingredients currently used and potentially usable in farm-made feeds; synthesis be carried out in respect of all available ingredients used on a regional basis taking into consideration factors such as seasonality, nutritional composition, price fluctuations (FAO/NACA/ and other regional organizations and or donor organisations);
- conduct a compilation and detailed review in a number of developing countries on the characteristics (ingredients, composition, methods of preparation, storage, efficacy, economics of performance) of currently used farm-made feeds. Such studies are expected to lead to compilation of better practice approaches on the use of farm-made feeds, on a regional basis (FAO/NACA/ and other regional organizations and or donor organisations);
- national institutions should be encouraged to undertake suitable research on formulation and improvements on proper and safe use of farm-made feeds and fertilizers;
- encourage and stimulate research on the nutritional requirements and feed and feeding related aspects of major cultured species. Relevant findings should be tested on farm before dissemination;
- compile and update available knowledge on the nutritional requirements of major cultured species in different regions (FAO); and
- where appropriate, use should be made of indigenous knowledge.

3. Extension, application and adoption

Organizations that interface with farmers or closely connected with farmers play an extremely important role and should be encouraged and supported in their work with regard to farm-made feeds and appropriate use of fertilizer. Acknowledging that the available extension materials are limited and often lack field testing, there is a need to identify and prepare appropriate extension tools with respect to the use of farm-made feeds. In order to achieve these objectives, the following actions may be taken by national and regional institutions:

- relevant extension materials developed and field tested with due considerations of cultural norms;
- in developing extension materials on the preparation of farm-made feeds and use of fertilizer, indigenous knowledge should be considered and farmers should be appraised of environmental concerns;
- use of mass media (e.g. radio, theatre, TV, newspaper) should be intensified;
- utilize existing successful demonstration units/farm as well as promote innovative farmers and use these farms as extension centres; and
- increased interaction between research and development (R&D) and farmers; and between farmers.

4. Capacity building

The full value of the use of fertilizers and farm-made feeds in rural aquaculture in developing countries has not been fully realized. There is an urgent need for capacity building for research and development and effective extension. These objectives could be achieved through the following actions by national and regional institutions:

- capacity building of extension officers and private service providers and NGOs through, e.g., specialized short term training programmes and workshops
- training on the preparation and use of farm-made feeds and fertilizers; and
- in certain regions such as Africa, there is a need for specialist capacity (e.g. specialized advanced training on fish nutrition and fish feed technology).

5. Private and public sector partnerships

Until now, there has been very little interaction between the private and the public sectors regarding the importance of farm-made feeds and fertilizers for the development

of rural and peri-urban aquaculture. The following will facilitate dialogue between the sectors:

- private (small-scale feed makers and other service providers) and public sectors need greater appreciation of the importance of farm-made feeds and fertilizers;
- provide a platform for dialogue between farmers and small scale feed producers and the animal husbandry industry through workshops (FAO/NACA/and other regional organizations and or donor organizations);
- encourage the establishment of farmer cooperatives/associations for on farm-made feed production; and
- provision of technical advisory services by public sector (agricultural agencies), e.g. providing printed/web-based information on supplier/market/price and other available services. To increase the responsibility of the public sector, using examples of lessons learned from other countries (e.g. leaflets, telecommunication, NACA/ACIAR booklet on grouper feed, etc).

The workshop recommended that FAO be tasked to take up the following actions to assist national governments and regional organizations:

- review existing national standards and legislation regarding the dietary nutrient specifications (where they exist) for the manufacture of compound aquafeeds/ farm-made aquafeeds for the major cultivated fish species, including the provision of guidelines and advisory material for different farming systems and feed types;
- review existing national mechanisms of incentives, subsidies and taxes affecting the animal feed manufacturing sector and feed ingredient usage, including feed ingredient imports and export/domestic promotion strategies;
- compile available information (in the form of synopses) on the dietary nutritional requirements of major cultured fish species and the feed ingredients currently used within compound/farm-made aquafeeds, including national/regional feed ingredient source books containing information on nutrient composition, quality control criteria, seasonality, and market price;
- encourage the strengthening of national/regional dialogue, exchange of information and research priority setting between researchers/public sector and the aquaculture sector (including farmers and feed manufacturers), through support to the activities of national/regional organizations, the implementation of joint research projects, the establishment of national farmer/aquafeed associations, and the development of web-based information and research networks; and
- strengthen capacity building in aquaculture nutrition and feed technology, including on-farm feed management, for farmers, feed manufacturers, private service providers, researchers and extension workers within developing countries (and in particular within sub-Saharan Africa). This may also respond well to inter-regional cooperation.

ACKNOWLEDGEMENTS

We would like to gratefully acknowledge all staff of the Freshwater Fisheries Research Centre and in particular Mr Miao Weimin, Deputy Director and Associate Professor Yuan Xinhua for their excellent cooperation and hospitality provided during the workshop. The Network of Aquaculture Centres in Asia-Pacific (NACA) is acknowledged for its active collaboration in organizing the workshop. The Ministry of Agriculture, Government of P.R. China is acknowledged for arranging the necessary government clearance for visas of all workshop participants. All participants actively participated in the workshop and contributed during the technical presentations and the working group sessions and we take this opportunity to thank all of them for their time and effort. The kind assistance and active contributions by Dr Simon Funge-Smith, Aquaculture Officer, FAO Regional Office for Asia and the Pacific, Bangkok, Thailand and Dr Melba Reantaso, Fishery Resources Officer (Aquaculture), FAO HQ, Rome, Italy is gratefully acknowledged.

ANNEX I
WELCOME REMARKS PROFESSOR XU PAO, DIRECTOR, FRESHWATER FISHERIES RESEARCH CENTER, CHINESE ACADEMY OF FISHERY SCIENCES, WUXI 214081, CHINA

Ladies and Gentlemen:
Good morning
FAO expert workshop on the use of feeds and fertilizers for sustainable development is now commencing in Freshwater Fisheries Research Center (FFRC), Chinese Academy of Fishery Sciences (CAFS), Wuxi, China. On behalf of Freshwater Fisheries Research Center, I'd like to extend a warm welcome to all the experts from FAO and other different countries.

Freshwater Fisheries Research Center, Chinese Academy of Fishery Sciences is one of the major comprehensive fisheries institutions for research, education/training, and information exchange. In the research activities, FFRC has the main functions oriented toward the basic and applied researches. The key research emphases are on fishery breeding biology and genetics, conservation of biodiversity and fishery stock resources, monitoring and protection of fishery environment, evaluation and management of fishery resources, fish disease prevention and control, carrying capacity and healthy aquaculture, fish nutrition and information exchanges etc.

Asian-Pacific Regional Research and Training Center for Integrated Fish Farming as an important component of Freshwater Fisheries Research Center, has continuously undertaken China-TCDC training courses for 25 years. Over 30 courses have been successfully conducted for more than 1000 participants from 80 countries, besides there have been also a great number of times of international academic workshops, visiting scholar exchanges and research collaborations.

Freshwater Fisheries Research Center is pleased to carry out collaboration in any forms on fishery research, technical training, and human resource development with all the specialists present at the workshop and assures the workshops of logistic services

Finally, I wish in advance the workshop a successful completion and good health of all the guests present at the workshop

Thank you

ANNEX II
OPENING REMARK OF MR LI JIEREN, VICE PRESIDENT OF CHINESE ACADEMY FISHERIES SCIENCE

Good Morning, Ladies and Gentlemen,
On behalf of Chinese Academic of Fisheries Science (CAFS), I would like to welcome all the colleagues, friends and participants, including international and national aquaculture feed and fertilizer experts, to attend this very important workshop in Wuxi and discuss the aquaculture related issues.

China is an important aquaculture country with a long aquaculture development history. Aquaculture has been documented more than 2000 year ago in China. At present, the total fisheries production reached 51 million, which about 67 percent come from aquaculture production. Aquaculture has become a very important component in the animal protein food production.

About 60 percent of natural fisheries resource has been damaged worldwide, it is declining in general and hardly to meet the demand for aquatic products through capture fisheries. Aquaculture contributes significantly to food availability, household food security, income generation, trade, and improved living standards in many developing countries, including China. The development of aquaculture has become more and more important in obtaining aquatic food for the people. Fisheries are transferring from capture fisheries to aquaculture, it just like the transferring agriculture from "collecting" to "farming" and from "hunting" to "animal husbandry". The development of aquaculture not only made its possible for increase of total fisheries production, but provides a complete new concept and efficient measure to reasonable utilization of water resources considering "expended ecosystem". The utilization of capture fishery resources is a process for use of solar energy by phytoplankton, in turn used by aquatic species in low-food chain to high food chain. The relationship for energy conversion and utilization among the species depends completely on a natural process. In aquaculture, feed technologies and various technical measures can be applied in the process of energy and food conversion to substantially improve the conversion ratio and food utilization so that the source of land-based plant feed can be introduced to the production of aquatic products. Therefore, the research and application on aquaculture technologies which consume less cost and energy and maximize aquaculture production will be required for seek of sustainable aquaculture development.

Aquaculture feeds and fertilizers as indispensable parts have played a very important role in the country's fisheries and aquaculture production and development. In China, Modern intensive aquaculture based on the aquaculture feed and nutrition has been practiced for about 20 years. But, China's aquaculture production depends largely on traditional aquaculture. Despite the country's reputation as a producer of large quantity aquaculture products and advanced traditional aquaculture technology, the aquaculture and its feed sector are faced with numerous problems hampering sector growth and development. These constraints include: (i) low-cost traditional pond aquaculture still remains as semi-intensive and poly-culture practice due to the low price of common food fish and slow economic development in rural areas; (ii) the application of a large quantity of single and family formulated feed still dominates aquaculture production; (iii) the aquaculture sector and its production are often developed and increased at the expenses of decrease of arable land areas; and (iv) under a highly-intensive aquaculture condition, the application of high-nutrient feeds and over-feeding practice often cause eutrophication and fish disease breakout in waterbody, and in turn result in environmental pollution and other problems due to lack of experience for special high-value aquatic species and inadequate studies on nutrition physiology and metabolism of target species.

A. The achievements made in animal feed and nutrition research in China

Let me to brief you what work have been done and achievements made in animal feed and nutrition research in China. China has commenced the studies and research on aquaculture animal feed and nutrition since 1980s. The major researches conducted include: nutrition requirement of fish and shrimp and feed formulation, the quality control and inspection of aquaculture animal feeds, alternative source of plant feeds, alternative biological feed and its culture techniques for aquaculture nursery, and biological feed and supplementary feed for polyculture system. These developed technologies are being widely applied in aquaculture production. These major achievements also include:

i) Obtained the nutrition requirements of major cultured-animal species at their different growing stages and the key nutrition parameters of supplementary feeds to provide scientific basis for the formulation of applied feeds;
ii) Developed technical standard and criteria for the quality control and inspection of aquaculture feeds and feed biological comprehensive assessment and established a number of feed inspection agencies at national and provincial levels to standardize the feed production;
iii) Produced several kinds of fish feed additive and pre-mixed feeds to expend the feed sources and improve feed quality;
iv) Produced various sinking and floating artificial feeds and commercial feeds for well-known and special high value cultured-species;
v) Cleared the nutrition value of sources of aquaculture feed and conventional aquaculture feeds and tested the energy value, nutriment and digestibility of various feeds to provide scientific basis for the development of high-efficient and artificial supplementary feeds; and
vi) Commenced the introduction and conversion of international research outcomes and new technologies on the nutrition and feeds for commercial production of high-value marine animal.

B. Priority Areas for China's Aquaculture Feed and Nutrition Research

Future priority research areas on aquaculture feed and nutrition in China include:

i) to further conduct of aquaculture nutrition physiology and metabolism, specifically, the functions of micro-nutriment to provide reliable scientific basis for modifying nutrition requirement, formulating low-cost and high-efficient applied feeds and improving feed conversion ratio;
ii) to strengthen research on the relationships between nutrition and immunity, incretion, environment, aquaculture product and its value;
iii) to further conduct the research on the reduction of release of phosphorous to aquaculture and water system for environment protection and feeding strategy;
iv) to conduct research on formulation technology of alternative artificial microdot supplementary feeds to replace live biological feeds and utilization of sources of plant feed; and
v) for a long term, to conduct research on the technology to produce fish as feed.

As we all aware, aquaculture feeds and fertilizers play a very important role in the aquaculture sector. I fully believe that workshop will generate a number of meaningful and operational recommendations, including policy and institutional recommendations on aquaculture feed and fertilizer research during our discussions. These outcomes of the workshop will eventually accelerate the development of world aquaculture feed and fertilizer sector and promote the sustainable aquaculture development.

As a national research institution, CAFS has its responsibility for important basic and applied research and new- and high- technology developments for fisheries and aquaculture sector. It also plays a vital role in solving key and important sector and development issues within fisheries sector, and conducting national and international

fisheries and technology exchange, communications and collaboration programs. At present, CAFS has 9 research centers and 4 multiplication and experimental stations. Therefore, take the opportunity, I would like to invite you and welcome all of you, international and national experts to make our best effort to strengthen our research collaboration in aquaculture feed and fertilizer research and development to achieve our common goal and contribute to world sustainable aquaculture development and poverty reduction. Finally, I would like to wish to have a fruitful and fully successful workshop! Thanks

ANNEX III
FAO EXPERT WORKSHOP ON "USE OF FEEDS AND FERTILIZERS FOR SUSTAINABLE AQUACULTURE DEVELOPMENT"

Wuxi, Jiangsu Province, P.R. China, 18–21 March 2006

Agenda

time	ACTIVITY
17th March	
	Arrival of Participants in Wuxi
18th March - Workshop day 1	
08.00 - 08.30	Registration
Session I: Opening and Welcome Remarks	
08.30 - 09.00	• Master of ceremony – Yuan Xinhua • Election of Chair • Welcome address – Director, Freshwater Fisheries Research Centre • Opening remarks – Vice President, Chinese Academy of Science • Introduction of the participants • Group photograph
09.00 - 09.10	Introduction and Objectives of the Workshop – *Dr Mohammad R. Hasan*
Session II: Presentation of Country Reviews: Study and analysis of feeds and fertilizers for sustainable aquaculture development *Co-chair: Dr Sena De Silva - Rapporteur: Dr Melba Reantaso*	
09.10 - 10.10	Selected country reviews (20 minutes for each presentation) • China: *Mr Miao Weimin* • India: *Dr Syed Ahamad Ali* • Philippines: *Dr Neila S. Sumagaysay-Chavoso*
10.10 -10.30	Coffee/Tea Break
10.30 -11.50	Selected country reviews (20 minutes for each presentation) • Thailand: *Dr Supis Thongrod* • Viet Nam: *Dr Le Thanh Hung* • Egypt: *Dr Abdel-Fattah M. El-Sayed* • Uganda: *Dr Justus Rutaisire*
11.50 -12.30	General discussion on country reviews
12.30 -14.00	Lunch
Session III: Review of Development of Aquafeed Industry *Co-chair: Dr. Albert Tacon Rapporteur: Dr. Melba Reantaso*	
14.00 -15.00	• China: *Ms Liang Mengqing* • India: *Dr Syed Ahamad Ali* • Egypt: *Dr Abdel-Fattah M. El-Sayed*
15.00 - 15.20	General Discussion on review of development of aquafeed industry
15.20 - 15.40	Coffee/Tea Break
Session IV: Presentation of Regional Synthesis	
15.40 - 16.10	Feeds and Sustainability of Asian Aquaculture: *Dr Sena De Silva*
16.10 - 16.40	Developments in sub-Saharan African aquaculture: feeds and fertilizers: *Dr Thomas Hecht*
16.40 - 17.10	Aquaculture feeds in Latin America: a look at key elements at the macro (the industry) and micro (farm practices) levels: *Dr Alejandro Flores Nava*
17.10 - 18.00	General Discussion
18.00 – 20.30	Depart to Wuxi town for reception dinner

19th March - Workshop day 2	
Session V: Presentation of Case Study on Economics of Aquaculture Feeding Systems	
Co-chair: Dr Alejandro Flores-Nava - Rapporteur: Dr Thomas Hecht	
08.30 - 08.50	Case study on the use of farm-made feed versus commercially formulated pellets for *Pangasiid* catfish in the Mekong delta, Viet Nam: *Dr Le Thanh Hung*
08.50 - 09.10	The economics of small-scale aquaculture feeding systems in China: *Mr Yuan Xinhua*
09.10 - 09.40	An economic analysis of aquaculture feeding systems: a synthesis of three Asian countries: *Dr Walfredo Raquel Rola*
09.40 -10.10	Discussion
10.10-10.30	Coffee/Tea Break
Session VI: Invited Presentation and Global Synthesis	
10.30 -11.00	Invited presentation: Reducing waste production of aquaculture by improvement of feed formulation and feeding regime- *Dr Shouqi Xie*
11.00 -11.30	Feeds and nutrients for sustainable aquaculture development within developing countries: a global synthesis: *Dr Albert G.J. Tacon*
11.30 -12.00	General Discussion
Session VII: Working Group Discussions	
12.00 -12.30	Mechanisms and guidelines for Working Group (WG) Discussions: *Dr Simon Funge-Smith*
12.30-14.00	Lunch
14.00 -18.00	Working Groups break up for discussions

20th March - Workshop day 3	
Session VII (cont.): Working Group discussions	
Co-chair: Dr Mohammad R. Hasan - Rapporteur: Dr Simon Funge-Smith	
09.00 – 10.30	Working Groups continue and preparation for plenary presentation
10.30 -10.45	Coffee/Tea Break
10.45 -11.15	Working Group I – presentation to plenary
11.15 -12.15	Working Group II - presentation to plenary
12.15 – 12.30	Short plenary discussion to prepare for afternoon session
12.30 -14.00	Lunch
14.00-15.00	General Discussion Working Group Presentations Identification of key points for action
15.00 -16.00	Working Group Chairpersons, Rapporteurs and Technical Secretariat to finalize Workshop Recommendations
Session VIII: Presentation of Final Workshop Recommendations in Plenary	
Rapporteur: Dr Simon Funge-Smith	
16.00 -17.30	Short presentation of summary recommendations of the workshop Discussion Closing
18.00 – 20.30	Depart to Wuxi for closing dinner

21st March - Workshop day 4	
08.30 -18.30	All-day field visit to feed machinery manufacturing plant, feed mill and fish farm

22nd March	
	Participants depart Wuxi

ANNEX IV
PROCEDURES FOR WORKING GROUP SESSIONS

For the working sessions, workshop participants were divided into two groups. Each group examined one or more thematic area(s) assigned to them, and were requested to identify critical issues and prepare specific recommendations and follow up actions and to present these in the final plenary session. A number of background documents were circulated among the participants prior to and during the workshop.

Thematic areas assigned to the Working Groups

Working Group A: Industrial aquafeed- development of the industry, impact of availability of protein sources, alternatives and their feasibility

Working Group B: Farm-made aquafeeds (including manures and fertilizers) -opportunities and constraints, availability, feasibility and management

Recognizing that aquaculture practices and farming systems vary widely between and within regions (Asia, Africa and Latin America) working group participants were requested to consider the following general issues during their discussions:

- limited land area will prohibit further horizontal expansion of aquaculture in Asia;
- resources (feed and fertilizers) are limited and competition with other resource users (poultry, livestock and crop) will increase;
- bulk of aquaculture production in Asia and over 80 percent of fish produced in Africa depend on farm-made aquafeeds and this is likely to continue in the foreseeable future;
- in Asia, market price and demand often makes it uneconomic to use industrial feeds while in Africa it is constrained by economies of scale and the lack of critical mass; and
- farm-made feeds are rarely used in Latin America and greater use of farm-made feeds may provide opportunities for small-scale farmers.

The working groups were specifically also requested to consider the following issues:

Working Group A: Development of the aquafeed industry

- Dependence of industrial aquafeeds on key feed ingredients (fishmeal, fish oil, SBM)
- Impacts of availability of key feed ingredients on industrial feed based aquaculture
- Realistic alternatives of fishmeal and fish oil (except SBM) and the best approach to translate the results into practise
- Quality assurance of locally produced industrial feed

Working Group B: Farm-made aquafeeds

- Improving feed quality
- Economic and environmental issues related to the use of farm-made aquafeed vs. industrially manufactured feeds.
- Improvement in feeding and feed management practices
- Development of location/region-specific appropriate farm-made feed formulations through focused research.
- Extension and support services to small (farm-made)- to medium-scale aquafeed producers to improve their production processes and technologies

After the general discussion of the working group presentations in the plenary the WG Chairpersons, Rapporteurs and the technical secretariat finalized the workshop recommendations that were approved during the final plenary session.

ANNEX V
LIST OF PARTICIPANTS

AUSTRALIA Dr Sena S. De Silva, Professor, School of Ecology and Environment, Faculty of Science & Technology, Deakin University Warrnambool, Victoria, Australia. Tel. +61 (3) 556 33527. E-mail: sena@deakin.edu.au	**MEXICO** Dr Alejandro Flores Nava, Rector, Universidad Marista de Merida, Calle 14 No. 128 x 5 y 9 Fracc. Montecristi, Mérida, Yucatan, 97000 Mexico, Tel. 52-999-9412026, Fax: 52-999-9410307. E-mail: aflores@marista.edu.mx
CHINA Miao Weimin, Deputy Director, Freshwater Fisheries Research Centre, Qitang North No. 1, Wuxi, P.R. China, 21408. Tel. (86) 510-5878390. Fax: (86)510-5555112/ (86)510-5553304. E-mail: miaowm@ffrc.cn, wmmiao@public1.wx.js.cn	**PHILIPPINES** Dr Neila S. Sumagaysay-Chavoso, University of the Philippines Aquaculture Society, Gabinete Residence, Miramar Subdivision, Jaro 5000, Iloilo City, The Philippines. Tel. No. (063) 335096700. E-mail: neila_sc@yahoo.com.sg
Yuan Xinhua, Associate Professor, Freshwater Fisheries Research Centre, #9. Shanshui Xi Rd., Wuxi, Jiangsu Province, P.R. China 214081. Tel. +86-510-5555796/2281121; Fax: +86-510-5555796. E-mail: yuanxh@ffrc.cn	Dr Walfredo Raquel Rola, Department of Community and Environmental Resource Planning, College of Human Ecology, UPLB, Los Banos, Laguna, Philippines 4031. Tel. +63-049-536-1622. E-mail: wallyrola@yahoo.com
Ms. Liang Mengqing, Yellow Sea Fisheries Research Institute PO Box: 266071,106 Nanjing Road,Qingdao, P.R. China. E-mail: liangmq@ysfri.ac.cn	**SOUTH AFRICA** Dr Thomas Hecht, Professor Emeritus, Dept. Ichthyology & Fisheries Science, Rhodes University, Grahamstown, South Africa Tel. +27 (0) 46 6038415 (W) +27 (0) 46 6751010 (Home). E-mail: T.Hecht@ru.ac.za
Dr Shouqi Xie, Institute of Hydrobiology, The Chinese Academy of Sciences, Wuhan, Hubei, 430072 P.R. China, Tel/Fax: +86 27 68780667. E-mail: sqxie@ihb.ac.cn, sqxie@public.wh.hb.cn	**THAILAND** Dr Supis Thongrod, Director, Coastal Aquatic Feed Research Institute, Department of Fisheries, 41/14 Moo 9, Bangphra District, Sriracha, Chonburi Province 20110, Thailand. Tel. 66-38-312532, Fax: 66-38-312532. E-mail: supist@fisheries.go.th, supisthongrod@yahoo.com
EGYPT Dr Abdel-Fattah M. El-Sayed, Professor, Oceanography Department, Faculty of Science, Alexandria University, Alexandria, Egypt. Tel. 00203-4273858; 002012/1699648, E-mail: a_elsayed50@yahoo.com	**UGANDA** Dr Justus Rutaisire, Senior Lecturer, Makerere University, Department of Wildlife and Animal Resources Management, Faculty of Veterinary Medicine, P.O. Box 7062, Kampala, Uganda. Tel. +25677501227/+25677634077, Fax +25641533402. E-mail: jruta@mulib.mak.ac.ug; jusruta@yahoo.com
INDIA Dr Syed Ahamad Ali, Principal Scientist & Head, Nutrition Genetics and Biotechnology Division, Central Institute of Brackishwater Aquaculture (CIBA), 75, Santhome High Road, RA Puram, Chennai 600 028, India, Tel. 091-44-24618817, 24616948, 24610565, Fax: 091-44-2461031. E-mail: Ali_madras@yahoo.com, ciba@tn.nic.in	**UNITED STATES OF AMERICA** Dr Albert G.J. Tacon, Aquatic Farms Ltd, 49-139 Kamehameha Hwy., Kaneohe, Hawaii 96744 United States of America. Tel. +1-808-239 2929, Fax: +1-808-235 0177. E-mail: atacon@hawaii.rr.com; AGJTACON@aol.com

VIET NAM Dr Le Thanh Hung, Vice Dean, Faculty of Fisheries, Nong Lam University, Linh Trung Ward, Thu Duc District, HCMC, Viet Nam, Tel. 84-8-7220733/ 84-8-8657570. E-mail**:** lthungts@hcm.vnn.vn	**NETWORK OF AQUACULTURE CENTRES IN ASIA-PACIFIC (NACA)** Zhuo Xiaowei, Programme & Operation Manager, Network of Aquaculture Centres in Asia-Pacific, P.O. Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand Tel. +66-(0)2-5611728 ext 111; Mobile: +66-(0)9-8153750, Fax: +66-(0)2-5611727. E-mail: xiaowei.zhou@enaca.org
FAO REGIONAL OFFICE FOR ASIA AND THE PACIFIC (FAORAP) Dr Simon Funge-Smith, Aquaculture Officer, FAO Regional Office for Asia and the Pacific, 39 Phra Athit Road, Bangkok 10200, Thailand. Tel. +662-6974149, Fax:+662-6974445. E-mail: Simon.Funge-smith@fao.org	**NON-GOVERNMENTAL AND PRIVATE ORGANIZATIONS (NGOs)** Dr Chawalit Orachunwong, Chareon Pokphand Foods Co. Ltd., 69/1, M4, Tambon Klongjig, Bang-Pa-In Ayudhaya Province, Thailand 13160. E-mail: fishtech@loxinfo.co.th
FISHERIES DEPARTMENT, FAO headquarters Dr Melba Reantaso, Fishery Resources Officer (Aquaculture), Aquaculture Management and Conservation Service, Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy, Tel. (39) 06 570 54843, Fax: (39) 06 570 53020. E-mail: Melba.Reantaso@fao.org	Dr Michael Cremer, Technical Director-Aquaculture, U.S. Soybean Export Council, 9705 Eagle Creek Road, Leavenworth, WA 98826, United States of America, Tel. 509-548-5863, ; c/o American Soybean Association - International Marketing, 1802 SITC, No. 2201 Yanan Xi Lu, Shanghai, P.R. China 200336, Tel. 86-21-621. E-mail: mycremer@earthlink.net
Dr Mohammad R. Hasan, Fishery Resources Officer (Aquaculture), Aquaculture Management and Conservation Service, Fisheries and Aquaculture Department, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy, Tel. (39) 06 570 56442, Fax: (39) 06 570 53020. E-mail: Mohammad.Hasan@fao.org	

ANNEX VI
TECHNICAL SECRETARIAT

A technical secretariat comprising of Dr Mohammad R. Hasan (Aquaculture Management and Conservation Service, FAO Fisheries and Aquaculture Department), Dr Simon Funge-Smith (FAO Regional Office for Asia and the Pacific) and Dr Melba B. Reantaso (Aquaculture Management and Conservation Service, FAO Fisheries and Aquaculture Department) was responsible for technical coordination.