**Sustainable Integrated Kyusei Nature Farming EM Technology and Food Security in Africa**

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**Abstract**
Against the background of varying rainfall patterns and the lack of adequate water in various communities, the principles and value of integrated farming systems are discussed. Attention is paid to the incorporation of EM-technology into these systems and the value it may have to enhance food production and the quality of life of the people in Africa.

**Introduction**
Africa is a fascinating continent renowned for its diversity in geographical features, climate, vegetation, animal life and people. This continent which is rich in natural resources has the potential to be prosperous and support its people nutritionally and economically.
This possibility creates exciting challenges for those of us in Africa who are committed to reverse the present tide of devastation, hunger and misery which are often attributed to political upheavel but which may have its origin in poverty and an unstable socio-economic environment. The extent of the challenge is amplified by Qureshi (1996) of the FAO, when he states that human poverty is the main obstacle in achieving success in Africa being poverty of access to food, a will to produce and a vision to conserve and to share resources. The poverty related hunger, social disruption, production slump and degradation of agricultural resources in Africa, are often highlighted as now in Zaire, where poverty was the cause of the rebellion, despite the fact that its southern Shaba region has some of the richest reserves of copper and cobalt n the world (Schoombee, 1997). The GNP per capita is estimated to be $125 making Zaire the fourth poorest country in the world (Schoombee, 1997)
Though Table 1 represented a bleak situation for a country like Zaire, it must be remembered that Africa is a continent with 57 countries of which 53 are independent, of which many are developing or developed.

**Table 1. GDP and Inflation in Zaire (Du Toit, 1997)**

| Year | GDP | Inflation |
|---|---|---|
| 1990 | -2.4 | 80 |
| 1991 | -12.3 | 2154 |
| 1992 | -10.4 | 4130 |
| 1993 | -12.6 | 1890 |
| 1994 | -7.4 | 23770 |

**Nutritional Patterns**
Globally a transition in nutritional patterns are recorded, where diets high in complex carbohydrates and fibre given way to more varied diets with a higher proportion of fats, saturated fats and sugars (Perisse *et.al.,* 1969; FAO, 1970; World Bank, 1993;). These shifts in diet structure accompany demographic shifts associated with higher life expectancy and reduced fertility rates. An associated epidemiological transition also takes place as patterns of disease shift away from infectious and nutrient deficiency diseases towards higher rates of coronary diseases (Omran, 1971; World Bank, 1993; Popkin, 1994 and Posner et al., 1994). Contrary to this scenario, one-third of the population in Sub-Saharan Africa is classified as chronically under-nourished (FAO, 1995). During 1970 to 1991 there was a negative change in the *per capita* production of all staple food commodities in 44 countries on the African continent. *Per capita* cereal production changed by 0.7 per cent per year; coarse grain by 0.8 per cent and cassava by 0.1 per cent.. However, per capita production of poultry, meat and eggs registered a positive growth of 3.1 per cent and 2.2 per cent respectively during this period. Concomitant with declining per capita food supplied there is wide-spread land degradation

on resource poor farms, while large and resource-rich farms also contribute substantially to resource degradation.

## Resources

Africa is however by no means resource poor. Qureshi (1996) states that the productive land per person is about 1.2 hectares, in addition to the marginally productive land of about 0.4 hectares. In the Middle and Southern Africa this figure is about 3-4 hectare per person (Table 2).

**Table 2. Land resources *per capita* (ha) (Qureshi, 1996)**

| | | Productive land | | Marginally productive | |
|---|---|---|---|---|---|
| | | **1989-1991** | **2010** | **1989-1991** | **2010** |
| Africa | (44) | 1.291 | 0,736 | 0.453 | 0.259 |
| Northern | (5) | 0.210 | 0.136 | 0.056 | 0.036 |
| Western | (15) | 0.858 | 0.475 | 0.365 | 0.202 |
| Middle | (5) | 4.090 | 2.271 | 1.073 | 0.596 |
| Eastern | (8) | 0.833 | 0.460 | 0.399 | 0.220 |
| Southern | (11) | 3.156 | 1.783 | 0.999 | 0.564 |

Despite the fact that Africa has its own resources, imports of foodstuffs and animal feeds registered a steady growth. Qureshi (1996) indicates that the present level of imports into Africa amount to more than US $ 650 million worth of live animals, $ 850 million of meat and meat products. $1.700 million of dairy products and eggs and $550 mlliion of feedstuffs per year. There are thus immense opportunities for import substitution and trade among African countries. Considering the above, it is evident why agriculture continues to dominate most economies and plays such a critical role in the achievement of sustainable economic growth.

## Water

One of the crucial resources in Africa is water. Though certain regions of the sub-continent may have a relatively high rainfall, a shortage or irregular rainfall is a factor to contend with in all agriculture endeavours as illustrated with the rainfall pattern of South Africa from 1910 to 1985 (Fig. 1). The mean annual precipitation in South Africa is depicted in Figure 2.

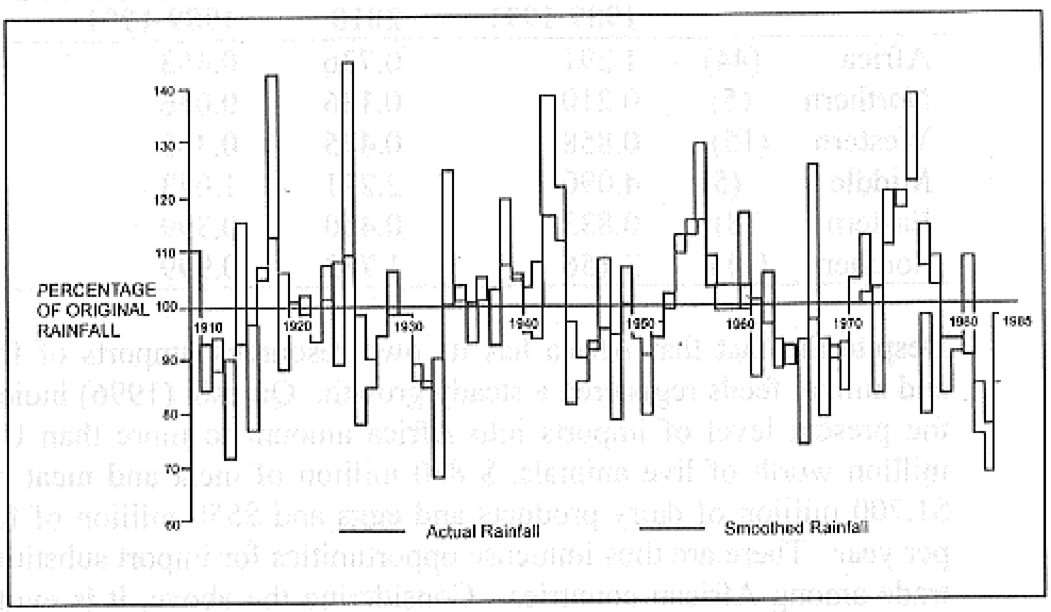



**Fig. 1. An Analysis of South Africa's Wet and Dry Cycles**

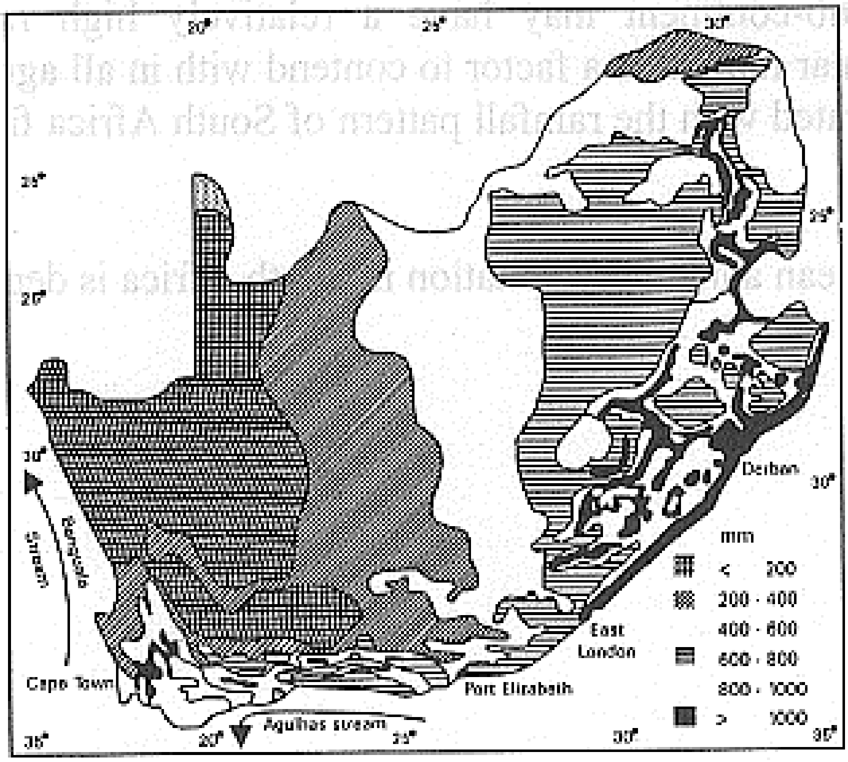



**Fig. 2. Mean Annual Precipitation**

Even though the Southern African region is a relatively small sub-region of the continent, five seasonal rainfall areas are identified in the RSA making water supply and the usage of runoff crucial in the food production programme (Fig.3). Optimal utilization, conservation and reuse of water is thus absolutely essential.

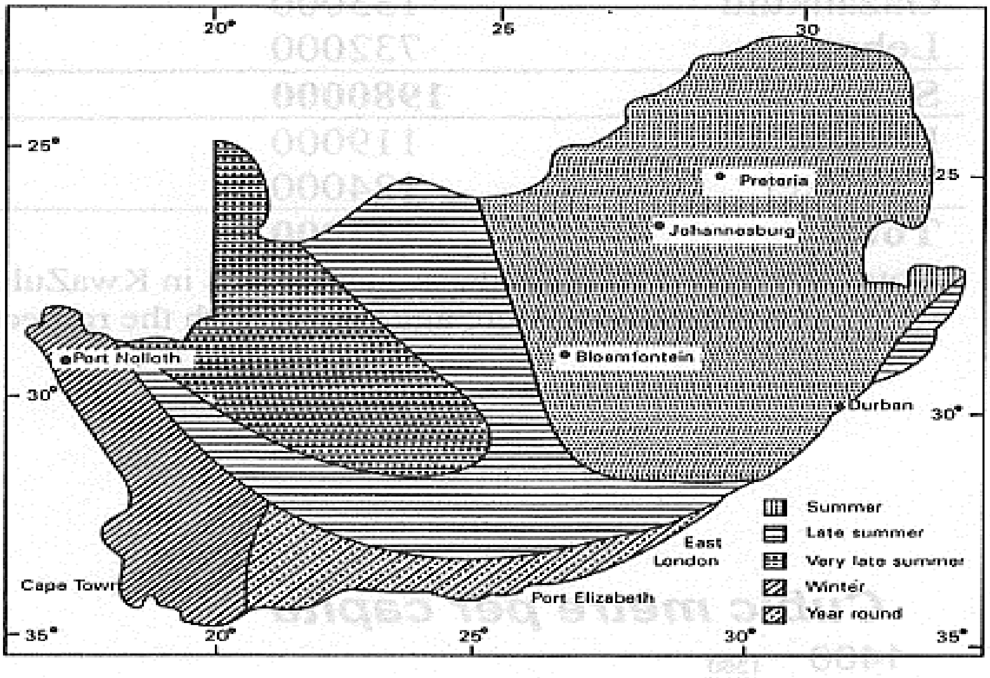



**Fig. 3 Seasonal Rainfall Regions**

Palmer and Eberhard (1994) indicate that at present a large percentage of the population in the RSA are already without adequate access to water. (Table 3).

If Fig. 4 presented by Cloete (1997) in which the availability of water to the population is given as correct, it is evident that the situation will become critical in the near future and the productive utilization of water will be of paramount importance in all sectors of the economy. Re-use and multiple use of water will have to become a way of thinking and advanced technologies will have to be implemented to improve productive utilization of water.

**Table 3. People Without Adequate Access in Dense Settlements (Palmer & Eberhard, 1994)**

| Dense Settlements | Dense Settlement Population | Population without Adequate Water Supply | Percentage |
|---|---|---|---|
| Bophuthatswana | 497000 | 330000 | 65 |
| Venda | 87000 | 72000 | 83 |
| Ciskei | 219000 | 66000 | 30 |
| QwaQwa | 125000 | 50000 | 40 |
| Kangwane | 187000 | 115000 | 62 |
| Gazankulu | 133000 | 85000 | 64 |
| Lebowa | 732000 | 600000 | 82 |
| **Subtotal** | **1980000** | **1318000** | **67** |
| KwaZulu | 119000 | | |
| Transkei | 124000 | | |
| **Total** | **2223000** | | |

Note: No information on dense settlements in KwaZulu and Transkei were found and these populations were aggregated with the respective town populations.

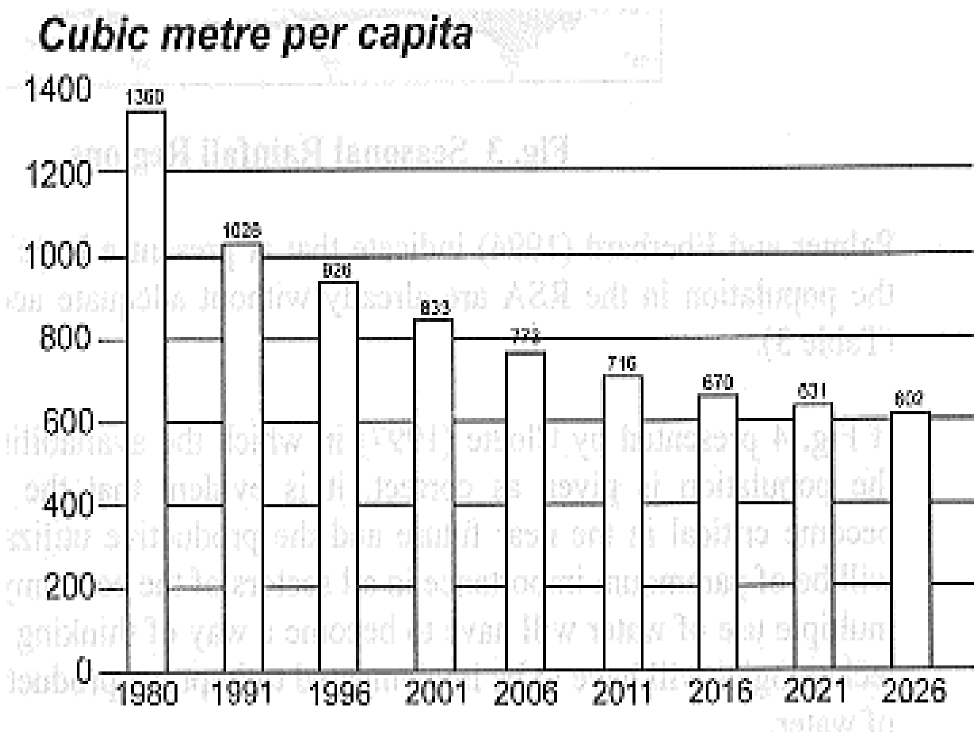
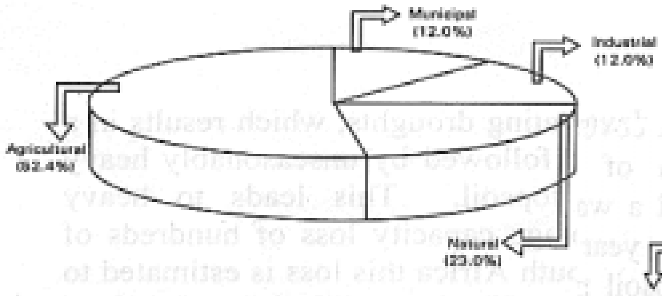
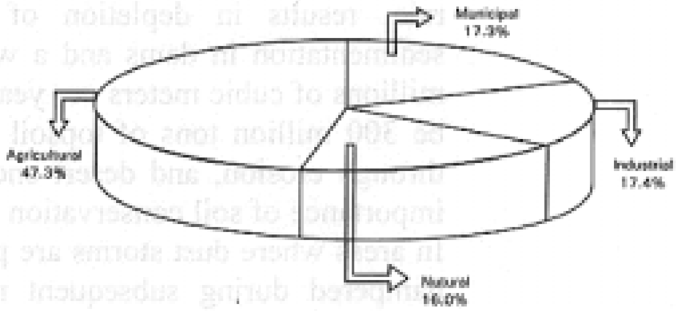



**Fig. 4 Decrease in Availability of Water in the RSA**

When considering the above situation, it is evident that the water usage pattern for South Africa as depicted in Figure 5 as an example of a southern African country, will also have to change.




Water use in South Africa (1990)
Total demand = 19000 GI




Water use in South Africa (2010)
Total demand = 25900 GI

**Fig. 5 Water Use in South Africa (1990-2010)**

The estimated contribution of irrigation, being the largest user of water to commercial crop production in South Africa, is given in Table 4.

**Table 4 Estimated Contribution of Irrigation to Commercial Crop Production in South Africa (Palmer and Eberhard, 1994)**

| Crop | Area Irrigated: X 1000 ha | Area Irrigated: % of Total Area Planted to this Crop in South Africa | Production: X 1000 t | Production: % of National Production |
|---|---|---|---|---|
| Maize | 110 | 3 | 660 | 10 |
| Wheat | 170 | 12 | 740 | 30 |
| Other small grains | 52 | 3 | 200 | 6 |
| Potatoes | 39 | 70 | 1200 | 80 |
| Vegetables | 108 | 66 | 1330 | 90 |
| Grapes | 103 | 90 | 1300 | 90 |
| Citrus | 356 | 85 | 1100 | 90 |
| Other fruit | 95 | 80 | 1200 | 90 |
| Oilseeds | 54 | 10 | 108 | 15 |
| Sugar-cane | 60 | 15 | 4000 | 25 |
| Cotton (Lint) | 18 | 17 | 17 | 42 |
| Tobacco | 12 | 85 | 20 | 90 |
| Lucerne | 203 | 70 | 1600 | 80 |
| Other pastures and forages | 104 | 15 | 800 | 25 |

**Vegetation**

The irregular rainfall pattern with devastating droughts, which results in a denuded soil with no plant cover, often followed by unseasonably heavy rain, results in depletion of fertile topsoil. This leads to heavy sedimentation in dams and a water storage capacity loss of hundreds of millions of cubic meters per year. In South Africa this loss is estimated to be 300 million tons of topsoil per year. The loss of fertile arable land through erosion, and desert encroachment in other areas (Fig. 6), emphasizes the importance of soil conservation and the improvement of more soil fertility. In areas where dust storms are prevalent, soil is lost and water penetration hampered during subsequent rainfall. Due to a loss of soil fertility deforestation is further encouraged in the ever increasing demand for more land while destruction of forests is hastened as the need for firewood in the rural and urbanized areas increase, where some women are walking more than 40 kilometres three times a week to collect firewood.

In the process, rural livelihood is destroyed, often leading to uncontrolled and unplanned urbanization. The high rate of urbanization (Table 5) has the largest population related impact on agriculture, particularly animal agriculture. The growth in demand for milk, meat and eggs is the highest mainly due to growth of urban populations and the increasing income levels of these populations.

**Table 5. Present and Predicted Percentages of Population Residing in Urban Areas –Africa and the World (Qureshi, 1996)**

| | 1995 | 2005 | 2015 |
|---|---|---|---|
| World | 45.2 | 50.0 | 55.5 |
| Africa (57) | 34.4 | 40.5 | 47.2 |
| Northern Africa | 45.9 | 51.0 | 57.3 |
| Eastern Africa | 21.7 | 27.6 | 34.1 |
| Southern Africa | 48.1 | 53.8 | 60.7 |
| Middle Africa | 33.2 | 39.1 | 46.7 |
| Western Africa | 36.6 | 44.5 | 52.3 |

Figure in brackets indicates number of countries.

The food production and supply situation is not only exacerbated by high population growth, but also by the distribution thereof. Although this trend is often not adequately reflected in country level statistics sustainable management of agricultural resources is certainly a major challenge in Africa.

**Livestock**

A disturbing phenomena is the fact that although an eighth of the world's population resides in Africa, and a similar proportion of world livestock is raised on the continent (Table 6) the livestock contribution to food supply is less than half the world average and it is proportionally declining (Qureshi, 1996). He further states that the average contribution of animal products to the world food supply in terms of both calories and protein, is increasing but the livestock contribution to the African diet is declining (Table 7).

**Table 6. African Share (%) of the World Livestock and Human Populations in 1995 (FAO-Agrostat)**

| | |
|---|---|
| Human population | 12.7 |
| Cattle and Buffaloes | 13.6 |
| Camels | 73.4 |
| Sheep | 19.2 |
| Goats | 28.9 |
| Pigs | 2.4 |
| Poultry | 8.1 |

**Table 7. Food Supply *per capita* per Day (Qureshi, 1996)**

| | Plant Products | | Animal Products | |
|---|---|---|---|---|
| | 1980 | 1992 | 1980 | 1992 |
| **Energy (cal):** | | | | |
| World | 2151 | 2290 | 408 | 428 |
| Africa | 2095 | 2151 | 190 | 169 |
| **Protein (gms):** | | | | |
| World | 43.8 | 46.2 | 22.99 | 24.6 |
| Africa | 44.1 | 44.1 | 13.0 | 11.9 |

Increasing food production is the mean challenge for Africa in the coming years, with livestock the key element in facing this challenge. Livestock integrated in farming systems contribute to increased food production from available resources, better family nutrition, greater utilization of labour, income generation and greater access to food for household security. Livestock utilize waste, crop residues, tree fodders and numerous by-products to produce high quality foods and thus enhance total food production. Qureshi (1996) further emphasizes the value of livestock integrated with crop, tree or forest farming, thus exploiting interesting complimentaries in resource utilization. For example, ducts combined with a fish pond, yield a higher amount of food energy and protein than the total of the two enterprises separately. Livestock's potential to increase total food production, including crop production, is increasingly being recognized. The Winrock assessment in 1992 and several other studies have pointed out that the greatest opportunity for expanding food production lies in mixed farming systems in sub-humid agroecozones, and the wetter portions of the semi-arid zones. Land-use intensification together with sustainable management of natural resources would be necessary to increase output from crop and livestock farming systems. Mohammed Saleem (1995) makes it clear that the mixed farming options should fully utilize the positive interactions between crops and livetock. Quershi (1996) indicates that increasing food production from farm households in Africa would require.

- Use of better technologies, which have been successfully tested at farm-level to significantly increase production per unit resource, ie. To make optimal use of available soil, water, plant, animal, labour resources.
- Technologies and enterprises which are within the capacity of the farmers to operate, which are socially acceptable and maintain the ecological base, thus do not degrade soils, do not deplete genetic resources and do not pollute air and water.
- Production, input, supply and marketing enterprises which would provide adequate income and are able to survive as a business at least in the short-term.
- Infrastructure development and policy support which would provide a level playing field from households compared to other segments of the economy.

Apart from the above requirements, a successful system should have the capability to develop human resources in the country and their quality of life, and should thus have a livelihood focus. This is a formidable and challenging task that requires a wealth of knowledge and experience and urgent attention to productivity improvement (Lundall, 1997).

**Integrated Systems**

That Africa is ready to accept this challenge is evident from a statement made by the President of South Africa, Mr. Nelson Mandela, at the 1994 meeting of the Organization of African Unity in Tunis, when he stated that Africa is screaming out for a new birth. "There are no obstracles large enough to prevent a new Africa renaissance". His vision is one of peace, democracy, equality and righteousness in a society which has escaped from poverty, disease, ignorance and backwardness (Esterhuyse, 1997; Van der Kooy, 1997). To support this vision, sustainable growth in food supply with minimal impact on the environment will be required (Hedin and Likens, 1996; Muller, 1997; Nobel and Rashidi, 1990). Integrated agricultural systems may be a very important element in the development and upliftment of Africa and to ensure sustainable growth in support of this vision.

In both developed and developing countries there are an increased competition for water resources resulting in deficiencies in supply and in various forms of pollution. In developing countries the nutritional potential of aquatic resources is however very important (Mitchell and De Silva, 1992). Food production systems are thus required which permit farmers to meet growing demands for food with technologies that are ecologically sound, protect the environment and conserve natural resources for future generations. Environmentally friendly and resource conserving integrated fish farming promises productive and profitable, yet sustainable aquaculture systems for both large –and small-scale farmers (Edwards, 1991).

Optimizing resource utilization in intensified sustainable food production, requires an integrated approach. Dalsgaard (1995) indicates that one of the appealing features of integrated farming, such as integrated agriculture-aquaculture, is that it leads to a concept where the farm is viewed in terms of interdependent components, ie. a system. This perspective is useful as systems can be described, modeled, analyzed and compared. The systems are guided by principles and have properties as a result of the parts they consist of and the way these parts are related.

Farms are agroecosystems and even if we adapt a narrow perspective that ignores the surrounding natural, human and socio-economic environment and limit out view to the biota of the farm itself, we find that these agroecosystems may be made up of a few (Fig. 7) or surprisingly many components (Fig. 8). These components may be combined or managed more or less separately. Crop by-products may be fed to animals and animal manure returned to the crop. Fish may feed on (harmful) insects, snails, earthworms and weeds or algae grown in manure-enriched water. In the latter situation poultry may be fed over fish ponds and then fertilize them. Bees may be integrated to pollinate flowers and produce honey as a valuable nutrient in family nutrition and as a cash income for the family.

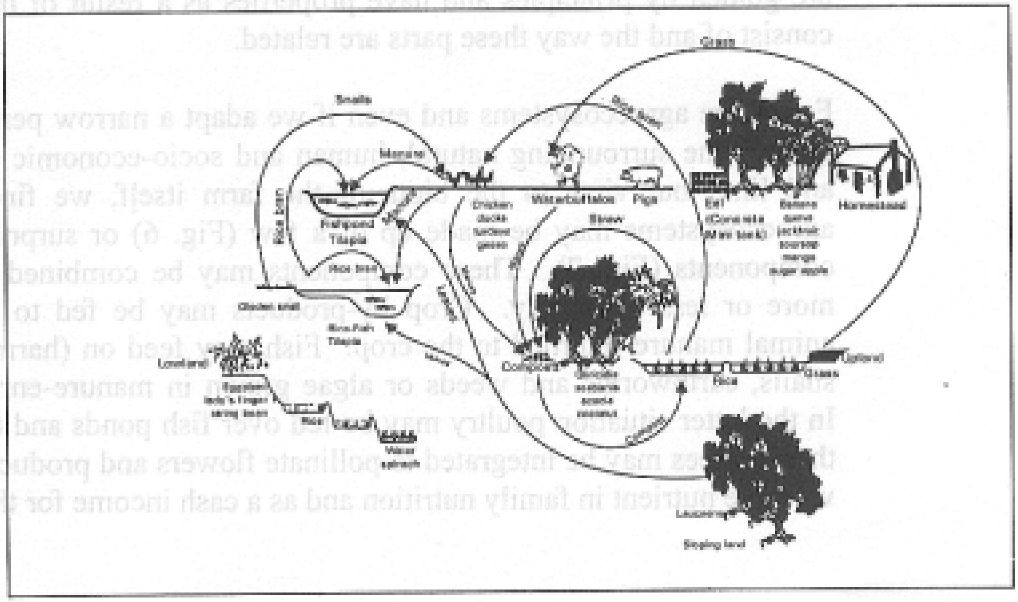



**Fig. 6 Bio-resource Flow Model of a Conventional Type Rice Farm**

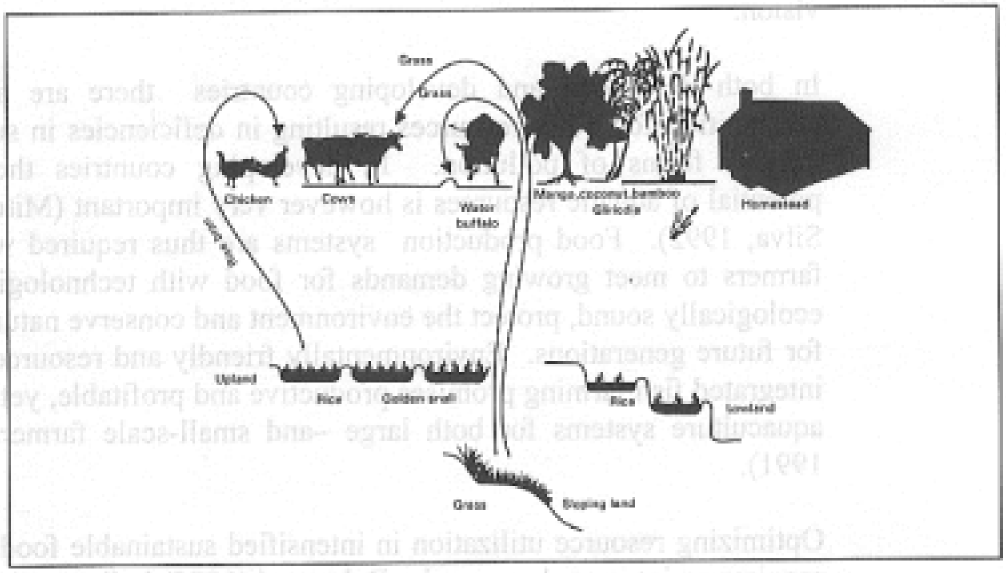



**Fig. 7 Bio-resource Flow Model of an Integrated Agriculture – Aquaculture Farm.**

The use of integrated farming has many benefits in improving the economic viability of the separate parts of the integrated operations (Little and Muir, 1987). Kestemont (1995) indicates that some distinctions may be made in agro-aquaculture systems according to whether integration is direct (use of the same area for different agro-aquaculture activities) or indirect (valorizations of by-products from other agricultural activities performed in other areas), or whether integration is parallel (use of the same area at the same time for both activities) or sequential (rotation of the different activities in the same area). Integrating aquaculture with other activities, plant or animal and fish farming, is particularly interesting with polyculture. This doesn't however exclude traditional monoculture with, for example, carp which has been associated with agriculture (rice, cereals) and duck farming in several regions of Europe, Japan and south-east Asia. Also in Africa, Brummett (1995) is of the opinion that integrated resource management (IRM) in general and integrated agriculture-aquaculture (IAA) in particular, may offer some solutions in cases where the classical methods if improving farm output have failed or have been unsustainable. Evidence indicates that integrated farms are more productive than non-integrated units operating on the same resource base. Increased food production on small-scale units increase the total amount of food available in a particular area and given producers the opportunity to improve their diet both quantitatively and qualitatively.

The improved productivity and efficiency of integrated farms over on-integrated ones, seem to imply that they should also be more profitable. Brummett (1995) states that this has been demonstrated on farms in several test cases. In the long-run, truly productive and sustainable technology should lead to increased prosperity among the better or more aggressive farmers.

According to Edwards (1991) an integrated agriculture-aquaculture system entails the interactions between the various sub-systems as depicted in Figure 9 and Figure 10. The focus of the system may thus be on different elements, but all are functioning interactions. Various integrated systems can thus be established. The success of the systems is determined by the total efficiency of resource utilization.

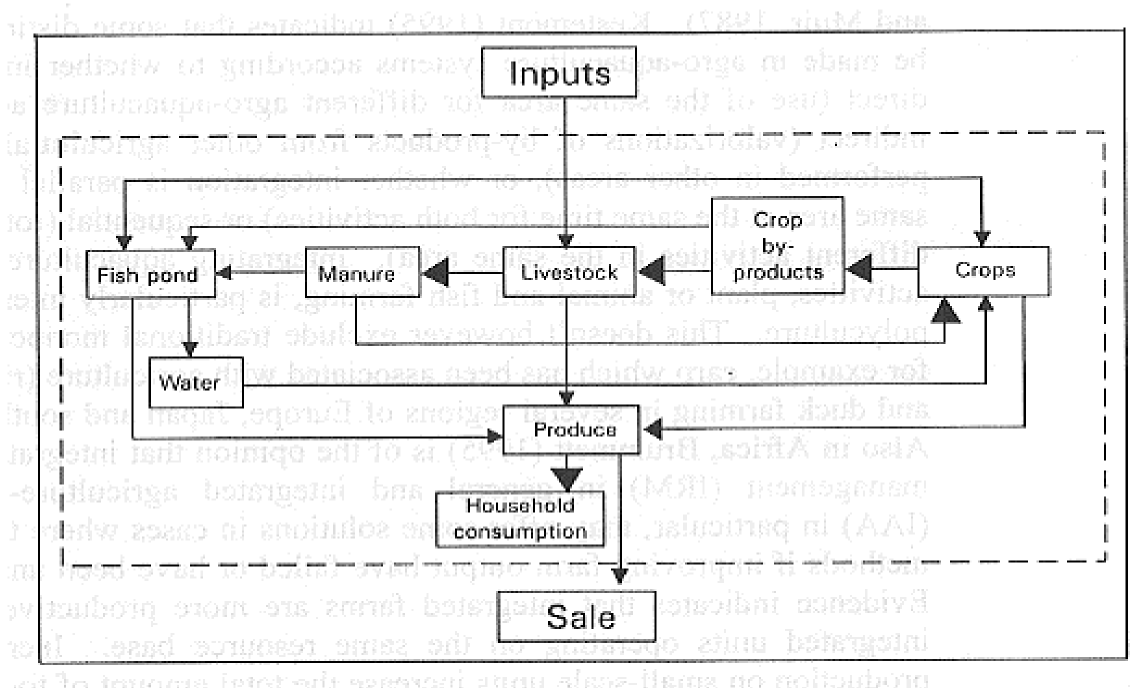



**Fig. 8. Major(or only) Interactions Between the Various Subsystems (thicker lines and shaded boxes) in a Crop-Dominated Small-Scale Farm (Edwards, 1991)**

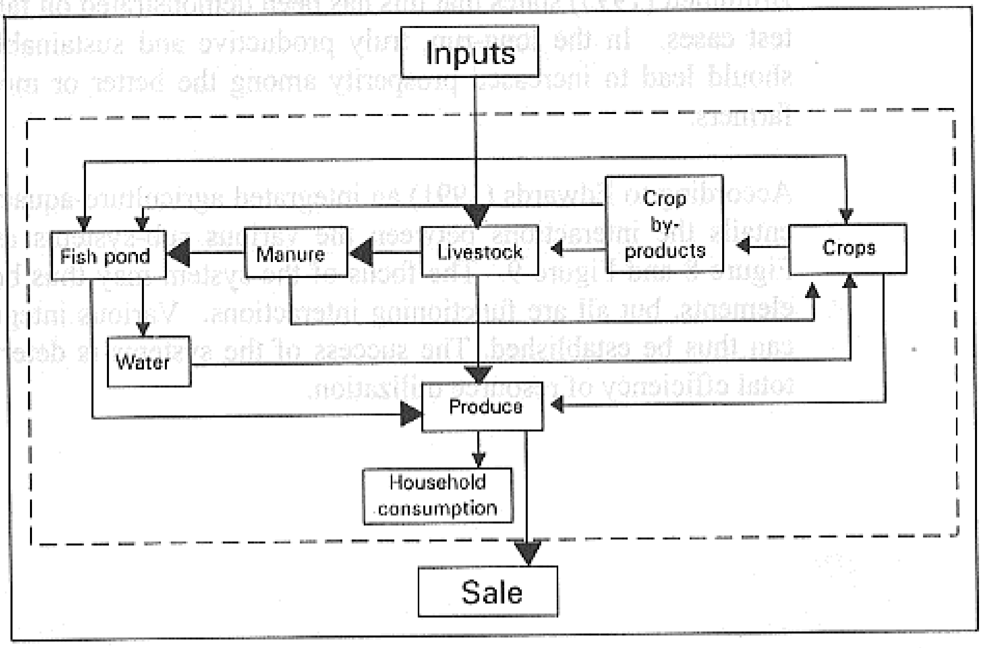



**Fig. 9. Major (often the only) Interactions Between the Various Subsystems (thicker lines and shaded boxes) in a Feedlot-Fish Integrated Farm (Edwards, 1991).**

The overall ability of the integrated agro-aqua system to produce biomass should thus be quantified. It's capacity reflects the quality of the underlying soil and the availability of water and may be quantified as biomass produced in kilogram per hectare. The biomass to energy ratio could thus be used to determine the efficiency of the system. The currency to be used in this evaluation could either be energy, nitrogen or energy, being short for embodied energy, which accounts for the energy required in the formation of organisms at different trophic levels (Odum, 1988), or the exergy which accounts for the genetic information accumulated within organisms (Jorgenson, 1992).

**Table 8. Nitrogen Efficiencies in a Theoretical Intensive System and Experimental Semi-intensive System (Edwards, 1991)**

| System | Treatment | Extrapolated Net Fish Yield (tonnes/ha/yr) | Nitrogen to Produce 1 kg/fish | Nitrogen Conversion Efficiency (percentage) |
|---|---|---|---|---|
| Intensive system: | FCR 1.0 | -- | 48 | 53 |
| | FCR 1.5 | -- | 72 | 36 |
| | FCR 2.0 | -- | 96 | 27 |
| | FCR 2.5 | -- | 120 | 21 |
| Semi-intensive system: | | | | |
| Integrated pig/fish | 100 pigs/ha | 7.1 | 103 | 25 |
| Integrated chicken/fish | 5000 birds/ha | 10.5 | 124 | 21 |
| Integrated duck/fish | 1500 birds/ha | 10.0 | 133 | 19 |
| Bagged chicken manure plus urea and triple Superphosphate | 8.5 kg manure dry matter/ha day and a total of 4 kg N and 1 kg P/ha/day | 8.6 | 170 | 15 |

Assumption: Pelleted feed contains 30 percent protein (dry weight basis); fish contains 16 percent protein (fresh weight basis); protein contains 16 percent nitrogen.

FCR: Feed conversion ratio (Kg of flesh produced per kg of feed supplied).

Edwards (1991) calculated the efficiency of a theoretical intensive system and an experimental semi-intensive system and reported the interesting values presented in Table 8.
The establishment of sustainable integrated system does however require a sound understanding of the structure and function of the aquatic ecosystems, be it mono- or polyculture systems (Mitchell and De Silva, 1992).

**Polyculture and Integrated Fish Farming**

Polyculture, which is the traditional method of fish culture in Asia (Lin, 1982), started in China during the Tang dynasty (AD 618-907) with the joint culture of bighead carp, silver carp, grass carp, common carp and other species with different food habits. Polyculture subsequently expanded with the introduction of Chinese carp to many countries for control of water quality and to increase fish production. Today Chinese carp have been stocked in ponds in Poland, Bulgaria, Hungary and France, while other carp varieties are used in production systems in Israel, India and in the USA (Kestemont, 1995). To cultivate different carp species in the same pond is of great interest, not only in terms of available food utilization, but also with respect to the utilization of all the ecological niches available in the pond ecosystem as surface, column or bottom feeders (Table 9). Moreover, due to positive interactions, the growth and yield of each species may be higher in polyculture than in a monoculture system. The synergistic interactions among fish species reared in polyculture are clearly explained by Milstein (1990), as quoted by Kestemont (1995).

**Table 9. Feeding Habits and Ecological Niche of the Different Carp Species (Kestemont, 1995)**

| Species | Feeding habits | Ecological niches |
|---|---|---|
| *Cyprinus carpio* | Omnivores | Bottom |
| *Ctenopharyngodon idella* | (benthos+detritus) | Surface |
| *Hypophthalmichthys* | Macrophytes | Surface |
| *molitrix* | Phytoplankton | Mid-water |
| *Aristichthys nobilis* | Zooplankton | Bottom |
| *Mylopharyngodon piceus* | Benthos | Bottom |
| *Cirrhina molitorella* | Benthos + detritus | Bottom |
| *Cirrhinus mrigala* | Omnivores | Surface |
| *Catla catla* | Zooplankton | Mid-water |
| *Lebeo rohita* | Omnivores | |

Polyculture is more relevant when integrated into well-established agricultural practices. In these integrated systems fish species can be manipulated to best utilize the particular waste available and thus are very efficient in the “Chinese AAA” system being aquaculture, animal husbandry and agriculture. Even hydroponic production of vegetables can be efficiently integrated in these systems (Brooke, 1994).
Conceptualization of impediments encountered in the implementation of multi-disciplinary structures or systems is however essential (Fig. 10).

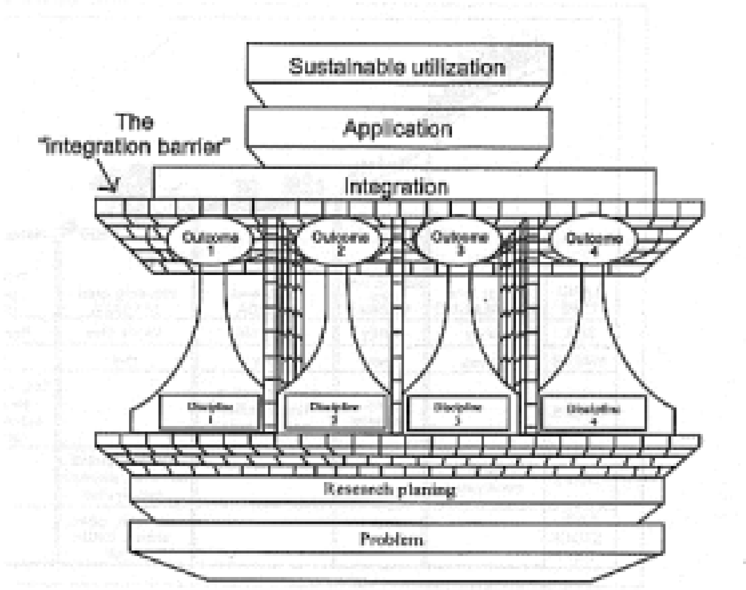



**Fig. 10. Conceptualization of Impediments to the Integration of Information in Multidisciplinary Studies. The "integration barrier" Shown as a Series of Brick Walls, Operates at Both the Research Planning and Completion Stages (Mitchell and De Silva, 1992).**

Only if these impediments are successfully overcome can a programme be designed which stresses the interrelationship of the physical, chemical and biological components of integrated aquatic systems and their catchments. A good example of this is a pig-duck-fish-azolla integrated system in the Philippines (Gavina, 1994) and in Malawi (Lightfoot, 1990). With respect to land types, farmers in the Zomna district in Malawi identified six land types from mountain to river plain. The agro-ecosystem analyst arranges the land types in sequence to form a "composite" transect listing all enterprises, soil and water characteristics (Fig. 12). This forms the basis for the design of an integrated agro-aquaculture system.

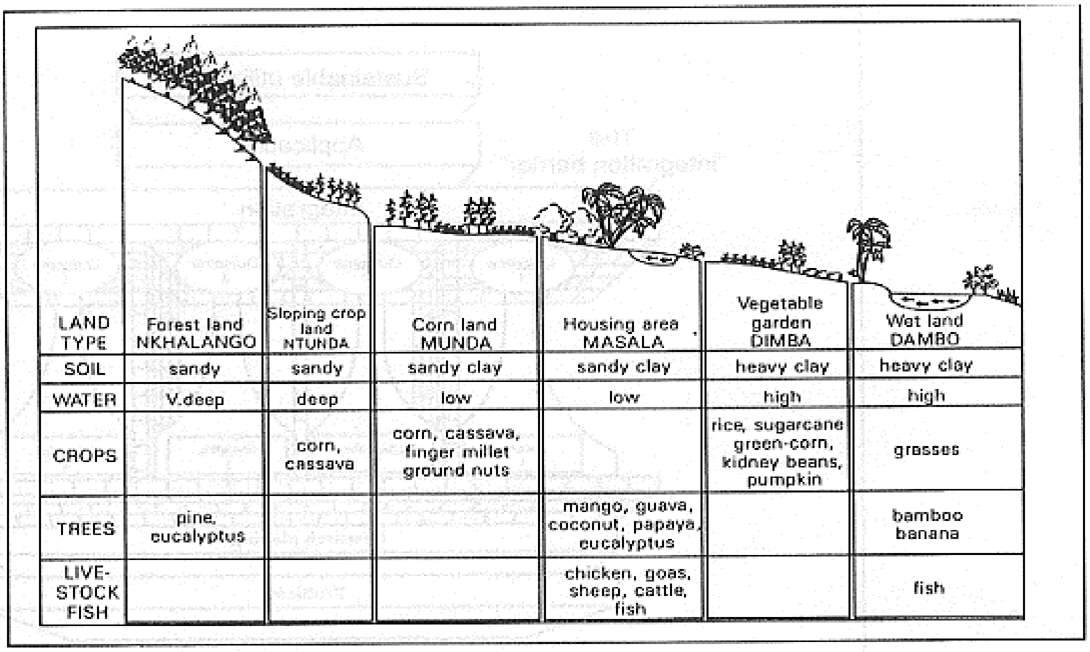



**Fig. 11. Agro-ecosystems Transect Zamba, Malawi (Lightfoot, 1990)**

An example of lviestock species successfully integrated into Tilapia farms in Rwanda, Honduras, Philippines and Thailand are given in Table 10 as well as an indication of the water source utilized (Table 11), feeding (Table 12) and fertilization practices (Table 13) which are being followed in these coutnries. The results of the survey conducted makes interesting reading and are presented in full in this paper as it may have far-reaching consequences in countries starting to implement these systems.

**Table 10. Enterprises on Tilapia Farms in Four Countries During 1994**

| | **Rwanda Pct.** | **Hondura Pct.** | **Philippines Pct.** | **Thailand Pct.** |
|---|---|---|---|---|
| **What type of farm animals do you raise ?** | | | | |
| Cattle | 83 | 62 | 32 | 15 |
| Goats | 78 | 5 | 32 | 0 |
| Pigs | 41 | 45 | 43 | 31 |
| Chickens | 23 | 69 | 80 | 51 |
| Ducks | 14 | 19 | 32 | 36 |
| Rabbits | 11 | 5 | 0 | 0 |
| Other | 19 | 12 | 50 | 8 |
| **Do you raise animals with your fish pond ?** | | | | |
| No | 100 | 72 | 60 | 31 |
| Yes | 0 | 28 | 40 | 69 |
| **What enterprises give most of cash income ?** | | | | |
| Vegetables | 0 | 49 | 36 | 9 |
| Rice | 0 | 2 | 56 | 36 |
| Bananas | 19 | 2 | 13 | 31 |
| Fruit Crops | 0 | 2 | 27 | 53 |
| Fish | 0 | 30 | 96 | 93 |
| Sugar-cane | 0 | 4 | 4 | 0 |
| Livestock | 0 | 34 | 25 | 62 |
| Corn/Maize | 10 | 15 | 9 | 0 |
| Other | 36 | 49 | 9 | 0 |
| Sorghum | 29 | 0 | 0 | 0 |
| Cabbage | 10 | 0 | 0 | 0 |
| Sweet potatoes | 83 | 0 | 0 | 0 |
| Beans | 10 | 0 | 0 | 0 |
| Taro | 16 | 0 | 0 | 0 |
| Cassava | 63 | 0 | 0 | 0 |
| Irish potatoes | 12 | 0 | 0 | 0 |
| Sweet peas | 9 | 0 | 0 | 0 |
| (Number) | (136) | (51) | (50) | (56) |

**Table 11. Pond Location and Water Source, Tilapia Farms in Four Countries During 1994**

| | Rwanda Pct. | Honduras Pct. | Philippines Pct. | Thailand Pct. |
|---|---|---|---|---|
| **How many ponds do you have on your land ?** | | | | |
| One | 84 | 16 | 9 | 39 |
| Two | 11 | 12 | 20 | 26 |
| Three or more | 5 | 72 | 71 | 35 |
| **What is the surface area of the ponds on farm ?** | | | | |
| <.25 hectare | - | 76 | 48 | 34 |
| .25 to 1 hectare | - | 20 | 48 | 58 |
| > 1 hectare | - | 4 | 4 | 8 |
| **Have you had problems getting enough water ?** | | | | |
| No | 76 | 82 | 66 | 45 |
| Yes | 24 | 18 | 34 | 55 |
| **Where are ponds in relation to house ?** | | | | |
| Next to house | - | 66 | 36 | 79 |
| < 1 kilometre | - | 12 | 35 | 6 |
| 1 to 3 | - | 2 | 22 | 9 |
| More than 3 | - | 20 | 7 | 6 |
| **What are the water sources for the ponds on this farm ?** | | | | |
| Well | - | 2 | 9 | 0 |
| Spring | - | 8 | 7 | 0 |
| River or stream | - | 18 | 14 | 2 |
| Lake – resrvoir | - | 48 | 0 | 2 |
| Irrigation canal | - | 14 | 13 | 64 |
| Collected runoff | - | 0 | 16 | 0 |
| Combination | - | 10 | 41 | 32 |
| **How was the water supplied to pond ?** | | | | |
| Pumped | 0 | 16 | 42 | 96 |
| Gravity flow | 100 | 82 | 38 | 2 |
| Combination | 0 | 2 | 20 | 2 |
| (Number) | (136) | (52) | (50) | (56) |

**Table 12. Feeding Practices, Tilapia Farms in Four Countries During 1994**

| | Rwanda Pct. | Honduras Pct. | Philippines Pct. | Thailand Pct. |
|---|---|---|---|---|
| **What are the Items most often fed ?** | | | | |
| Termites | 6 | 0 | 0 | 0 |
| Bees wax or larvae | 2 | 0 | 0 | 0 |
| Leaves | 87 | 0 | 0 | 0 |
| Manure | 67 | 0 | 0 | 0 |
| Sorghum beer waste | 32 | 0 | 0 | 0 |
| Kitchen waste | 0 | 14 | 2 | 12 |
| Fresh vegetation | 0 | 16 | 6 | 34 |
| Rice bran | 0 | 14 | 61 | 34 |
| Dead animals | 0 | 0 | 0 | 8 |
| Slaughter waste | 15 | 4 | 0 | 2 |
| Commercial feed | 0 | 41 | 32 | 42 |
| Chicken litter | 0 | 0 | 37 | 45 |
| Other | 8 | 57 | 0 | 2 |
| Grass cuttings | 28 | 0 | 0 | 0 |
| Compost | 28 | 0 | 0 | 0 |
| Inorganic N | 0 | 8 | 48 | 61 |
| Chicken feed | 0 | 0 | 2 | 0 |
| Fish feed | 0 | 0 | 0 | 0 |
| **Did you use commercial feed ?** | | | | |
| Only commercial | - | 21 | 10 | 7 |
| Mainly commercial | - | 10 | 24 | 20 |
| Both equally | - | 6 | 2 | 0 |
| Use no feed | 100[1] | 63 | 64 | 73 |
| **What type of commercial feed was usually purchased ?** | | | | |
| None purchased | 100[1] | 43 | 25 | 0 |
| Rice bran | 0 | 14 | 35 | 36 |
| Rabbit pellets | 0 | 8 | 0 | 0 |
| Chicken feed | 0 | 2 | 3 | 2 |
| Fish feed | 0 | 21 | 33 | 28 |
| Other | 0 | 12 | 0 | 34 |
| (Number) | (136) | (51) | (50) | (56) |

[1] Imputed data

**Table 13. Fertilization practices, Tilapia farms in four countries during 1994**

| | Rwanda Pct. | Honduras Pct. | Philippines Pct. | Thailand Pct. |
|---|---|---|---|---|
| **What type of pond fertilizer was used ?** [1] | | | | |
| Urea | - | 0 | 14 | 0 |
| 0-46-0 | - | 0 | 0 | 9 |
| 18-46-0 (dap) | - | 10 | 2 | 0 |
| Other N-P-K | - | 24 | 79 | 49 |
| Chicken manure | - | 29 | 70 | 53 |
| Cattle manure | - | 37 | 4 | 6 |
| Compost | - | 0 | 2 | 25 |
| **How often do you fertilize your ponds ?** | | | | |
| Several weekly | - | 27 | 0 | 69 |
| Weekly | - | 18 | 11 | 10 |
| Several monthly | - | 14 | 19 | 2 |
| Monthly | - | 10 | 21 | 0 |
| Less often | - | 21 | 43 | 4 |
| Never | - | 10 | 6 | 15 |
| **Were ponds limed last year ?** | | | | |
| No | - | 57 | 95 | 26 |
| Yes | - | 43 | 5 | 74 |
| **How often were ponds visited?** | | | | |
| Several daily | 0 | 39 | 34 | 73 |
| Every day | 53 | 37 | 36 | 119 |
| Almost every day | 2 | 14 | 25 | 0 |
| Several weekly | 32 | 2 | 5 | 6 |
| Once a week | 13 | 6 | 0 | 0 |
| Several monthly | 0 | 2 | 0 | 2 |
| **What time usually spent when you visit your pond ?** | | | | |
| Hour or less | 34 | 18 | 4 | 79 |
| About an hour | 48 | 30 | 5 | 11 |
| Two or 3 hrs. | 14 | 20 | 16 | 4 |
| More than 3 hrs. | 5 | 32 | 75 | 6 |
| (Number) | (136) | (51) | (50) | (56) |

[1] Multiple responses possible

**Kyusei Nature Farming and Integrated Systems**

Kyusei nature farming was developed in Japan with the objective of producing food that is safe and free of harmful chemicals and toxic materials.

The main theme of Kyusei nature farming is to practice “ideal agriculture” with the following five principles.

- To produce safe and nutritious food to enhance human health.
- To be economically and spiritually beneficial to both producers (farmers) and consumers.
- To be sustainable and easily practised by everyone.

- To conserve our environment.
- To produce sufficient food of high quality for an expanding world population.

When these principles are mirrored against those of the integrated systems it is evident that they will not only be extremely valuable in these systems, but that they support the concepts of an integrated system completely.

Integrated Kyusei nature farming systems will contribute significantly to increased food production from available natural resources, reduce environmental impact and improve access to food security, thus leading to better family nutrition. Available labour will be better utilized and house-hold income increased. Inclusion of the animal factor enriches the system and by incorporating the correct fish and livestock species will ensure the optimal utilization of crop residues, tree fodders and waste products. By integrating vegetables, crops, flowers, trees, fish, insects and livestock elements, the system exploits valuable synergies and complimentaries in resource use.

Employing multi-purpose crops like sugarcane can sustain a veriaty of livestock besides yielding sugar. Whereas the multi-purpose use of animals for food, fibre, farmpower, and soil fertility makes them most profitable and an indispendable factor in an integrated system. Improving the productivity of an integrated system, should always be a priority as the impact thereof on the communitry is very positive and amplified. The productivity of the system is further improved by utilizing waste from certain activities, *ie*. industries, agriculture or urban waste into feed (El Boushy and Van der Poel, 1994; Rammer *et al*, 1997).

**Effective Micro - organisms in Integrated Systems**

The productivity of the integrated system can be improved significantly by the use of effective microorganisms. Phillips and Phillips (1996) state that effective micro-organisms or Kyusei EM Microbial Inoculant is a mixed culture of beneficial organisms with the following principle micro-organisms being involved:

- Photosynthetic bacteria which are independent self-supporting micro-organisms. These bacteria synthesize useful substances from secretions of roots, organic matter and/or harmful gasses by using sunlight and the heat of soil as a source of energy. The useful substances secreted by the photosynthetic bacteria, amino acids, nucleic acids, bioactive substances and sugars, all of which naturally promotes plant growth and development.
- Lactic acid bacteria which produce lactic acid from sugars and other carbohydrates produced by photosynthetic bacteria and yeast. The lactic acid bacteria enhance the breakdown of complex organic matter such as lignin and cellulose and ferment these materials without creating harmful substances caused by putrefying organic matter.
- Yeasts which through their fermentation produce useful substances for plant growth from amino acids and sugars are found in soil, organic matter and the secretions of plant roots or photosynthetic bacteria. The yeast also produce bioactive substances such as hormones and enzymes which promote active cell and root division in plants.
- Actinomycetes is a group of micro-organisms which are intermediate in structure to bacteria and fungi. They produce anti-microbial substances from amino acids which are secreted by photosynthetic bacteria or found in soil organic matter. These anti-microbial substances help to limit the growth of harmful fungi and bacteria thus enhancing the quality of the soil environment.
- Fermenting fungi decompose organic matter rapidly to produce alcohol esters and anti-microbial substances. The growth of these fungi helps to control odours and prevent any infestation of harmful insects and maggots by eliminating their food supply.

It is evident that Kyusei EM has a valuable role to play in the integrated system and by its incorporation or integration the productivity of the system can be improved.

**Integrated Systems And Risk**

Castillo *et al.* (1992) draws attention to the fact that rural families who are most in need of improving their living conditions, are the most difficult to help. Small land-holdings, low educational levels and limited capital make these farmers unable or reluctant to adapt new technologies. These people cannot afford to risk their complete livelihood. Systems propagated for implementation in these areas should thus have a high probability of success with a low risk factor. The analysis of Castillo *et al*. (1992) is thus very informative indicating the value of integrated systems and the exceptional contribution to income which can be made with the integrating of mixed vegetable production (Table 14). The finding would support the concept of integrated Kyusei nature farming practices even though there are certain disadvantages that are outweighed by the advantages (Table 15.) The economic advantages and disadvantages of integrated systems are summarized in Table 15.

**Table 14. Financial and Economic Breakeven Prices and Yields for Six Enterprises on Production Areas of 100 m$^2$b (Castillo *et al*, 1992)**

| | Financial (cash items only)1 | | | | Economic (cash + non-cash items) | | | |
|---|---|---|---|---|---|---|---|---|
| | Unit price, $/kg | | Marketed yield[2] Kg/100m$^2$/yr | | Unit value, $/kg | | Yield kg/100m2/yr | |
| | Actual | Breakeven | Actual | Breakeven | Actual | Breakeven | Actual | Breakeven |
| Non-integrated fish | | | | | | | | |
| Low-nutrient | 1.33[3] | 0.32 | 18 | 4 | 1.33 | 0.74 | 30 | 17 |
| High-nutrient | 1.45[3] | 0.47 | 27 | 9 | 1.45 | 1.16 | 46 | 37 |
| Fish-poultry integrated | | | | | | | | |
| Fish –broilers | | | | | | | | |
| Broilers | 1.70 | 1.10 | 392 | 254 | 1.70 | 1.22 | 392 | 281 |
| Fish | 1.46[2] | 0.12 | 41 | 3 | 1.46 | 0.56 | 69 | 26 |
| Fish layers | | | | | | | | |
| Eggs[4] | 7.72 | 6.23 | 29 | 23 | 7.72 | 8.03 | 29 | 30 |
| Fish | 1.45[3] | 0.20 | 31 | 4 | 1.45 | 0.61 | 58 | 23 |
| Alternative crops[5] | | | | | | | | |
| Corn | 0.22 | 0.54 | 7 | 17 | 0.22 | 0.60 | 27 | 74 |
| Mixed vegetables | 0.04 | 0.01 | 1.805[6] | 559[6] | 0.04 | 0.03 | 2.407[6] | 1.456[6] |

[1] Variable cash costs for all enterprises were 95 to 100% of total cash costs.

[2] Marketed yield is the quantity actually sold or required to be sold to break even. The proportion actually sold of each product were: fish, 60%; poultry products, 100%; corn, 25%; mixed vegetables, 75%. The remainder was consumed at home.

[3] Weighted average price according to fish size

[4] Expressed in 100-egg units. Net cost for egg production was calculated as production cost minus receipts for spent layers. Financial breakeven prices and yields for eggs are calculated after subtracting spent layer cash receipts from total cash costs.

[5] Corn – 1 cycle; mixed vegetables – 2 cycles

[6] Yield is in number of vegetable units. Breakeven yield calculations assume weighted average vegetable market price of $0.042 per unit.

**Table 15. Summary of Economic Advantages and Disadvantages of Integrated and Non-integrated Fish Production and Alternative Crops (Castillo *et.al.*, 1992)**

| Non-integrated Systems | | Integrated Systems | |
|---|---|---|---|
| **Advantages** | **Disadvantages** | **Advantages** | **Disadvantages** |
| -less labour required | -water use only for fish production | -multiple water use is feasible | -capital intensive |
| -independence form off farm inputs | -lower production | -shorter breakeven time | -more technical skills |
| | | | -more economic risks |
| -fewer skills required | -fish production may be constrained by seasonal unavailability of some on-farm nutrients | -higher fish production | -more dependence on off-farm markets |
| -low star-up costs | | -greater income above variable costs | |
| -lower variable costs | -pond enrichment more labour intensive | -more frequent flow of cash receipts | -commercial feeds required |
| -higher returns - to - variable cost ratio | | -reduced labour for pond enrichment | |
| | | -lowest fish production costs | |

**Environmental Impact**

As a general rule, aquaculture and livestock integrated in a balanced way with other agricultural activities such as vegetable or crop production has a positive impact on the environment. The reason being that these systems valorizes waste coming from livestock or fish production systems. Most integrated systems use low levels of input, and thus have little environmental impact other than their occupation of former natural habitats (Pulin, 1989; Kestemont, 1995). However, when an aquaculture and for that matter any livestock component is incorporated in the integrated system, the impact on the environment must be minimized and controlled to ensure sustainability. An environmental impact assessment (Rosenthal, 1994; Doughty and McPhail, 1995) should however be done, the objective of which should be to:-

- Identify beneficial and adverse environmental impacts;
- Suggest mitigation actions which might reduce or prevent adverse impacts;
- Suggest measures which might enhance beneficial impacts;
- Identify and describe the residual inputs which cannot be mitigated;
- Identify appropriate monitoring strategies to track impacts and provide an early warning system;
- Incorporate environmental information into the decision process related to developmental projects; and
- Facilitate selection of the optimal alternative

Considering the above mentioned clearly focus attention on the benefit which may be incurred by incorporating Kyusei-EM technology into integrated systems.

**Integrated Systems and House-hold Security**

In integrated systems, fish, meat, milk, eggs, vegetables, cereals and honey could be produced which are excellent sources of nutrients crucially required by many households to meet the recommended dietary requirements of the family.

These products supply amino acids, vitamins, macro- and micro-minerals and energy essential for the wellbeing of the population. The products of the integrated system thus provide food security

and raise the nutritional status by providing important complementary ingredients for better nutrition particularly in developing countries such as Africa where the diet may be heavily dependant on one type of root crop such as cassawa or cereals such as maize (Qureshi, 1996).
A further benefit of the products produced in the integrated system is the additional income which is generated enabling the farmer to buy other foodstuffs which are not being produced by the family thus further increasing access to food, raising the standard of nutrition and ensuring a secure food supply for all members of the family. In this way co-prosperity is achieved and peaceful co-existence enhanced in the community.

**Socio – Economic Impact of Integrated Kyusei nature Farming Systems**
Integrated Kyusei farming systems may have a very positive impact on the socio-economic development of the people in Africa. It has the potential to generate more income and higher profits than monoculture practices.Tietze (1995) focused attention on the following social and institutional factors which are considered to play a role in fish farming and which can be extended to integrated systems and the marketing of the products:

- The social purpose of the integrated Kyusei nature farming is to contribute to the nutritional needs of the population and to achieve food security. Special attention should be paid to vulnerable groups in society characterized by low incomes, low social status and disadvantaged social position.
- Social factors which affect the demand for products such as habits and preferences of specific consumer groups should be understood and practices adapted to be acceptable and valuable to the specific community.
- Traditional groups of intermediaries in domestic marketing operations, their specific roles with regard to marketing and provision of finance as well as their social links to each other must be studied. Regulatory and administrative arrangements with regard to food inspection and quality control mush be adhered to.
- Activities of public enterprises in the field of procurement auctioneering, storage and distribution of produce.
- Infrastructure facilities for handling, storage, distribution and marketing of products in the integrated system.

Though information on the employment benefits of integrated systems are not well-documented, the integrated Kyusei nature farming system provides supplementary employment and income to men, women and children. The valuable role of women in the integrated Kyusei farming system and the value of the system to the women *per se* cannot be over emphasized. Studies in Cambodia indicated that women could do most of the operations independently with only minimal assistance from male family members (Nandeesha *et al*., 1994). Proper training of the women is however essential as studies in Bangladesh indicated (Monan and Price, 1995). In Bangladesh the involvement of women in integrated farming systems was a considerable breakthrough in the development process. The most important aspect of the project was, however, the integration of human development and economic activity in the training programme of the women. It was felt that if agriculture objectives alone were the focus of the women's involvement, they would have lacked the social and psychological strength to confront men who often would have wrestled economic control from them.
In South Africa we have implemented the Oasis Project which has the objective to ensure sustainable food production, develop the human resources in poor and disadvantaged communities enable the co-existence of diverse communities and improve the quality of life of all the people. An integrated system is used as a training base where men, women and children are trained to develop an integrated system but at the same time are trained and developed in a cascading process of life skills development, and entrepreneurial training. The process is summarized in Table 16.

**Conclusion**

Integrated Kyusei EM nature farming is a very valuable vehicle for sustainable food production in Africa. It's implementation in rural, peri-urban and urban agriculture would ensure the optimal utilizing of production resources, sustained food production and food security, in an environmentally friendly manner.

It would further lead to the improving agricultural output and food production of the people in Africa, their nutritional status and wellbeing will be enhanced. By-products could be used in handicraft manufacturing, an art form the African people are very gifted with., By further incorporating the human resource development element as in the Oasis Project, the quality of lives of the people will be improved, thus contributing to an African renaissance a true "Earth Saving Revolution" (Higa, 1996).

**OASIS PROJECT**

**Table 16. Human Resource Development Through Agriculture**

| | **Food Production Component** | **Business Component** | **Life Skills Component** |
|---|---|---|---|
| Green fingers certificate | Principles of vegetable production | | Introduction to life skills |
| Green hands certificate | Basic botany<br>Choice of vegetables<br>Composting methods<br>Fertilizers<br>Pest control | Production definition<br>Product quality<br>Product presentation | Leadership skills<br>Goal setting |
| Marketeer's certificate | Principles of aquaculture | Basic marketing principles<br>Acquiring product to market | Communication skills<br>Relations<br>Selling skills |
| Entrepreneur's certificate | Basic poultry production | Basic entrepreneurial skills<br>Business plan | Time management<br>Problem solving |
| | Advanced aquaculture | Price determination<br>Cash flow<br>Business evaluation | Decision making |
| High flyer's certificate | Advanced aquaculture and poultry prodcution | Contracts<br>Market development<br>Personnel management<br>Computer literacy | Conflict management<br>Stress management<br>Love and respect for nature |

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