External Benefits of the Application of the technology of Effective Microorganisms (EM) in Agriculture

Francisco Aguilar[1]

[1] *The Royal Agricultural College, Cirencester UK. GL7 6JS. Contact e-mail:Jaguilar@gye.satnet.net*
Mailing address: P.O.Box 09 04 936, Guayaquil, Ecuador

Abstract
An externality can be defined as any action that affects the welfare of Society without direct payment or compensation. The agricultural sector produces externalities that could be positive or negative to the Society. The technology of Effective Microorganisms (EM) was assessed to estimate its environmental benefits - positive externalities- based on reports from the International Conferences on Kyusei Nature Farming. Next, a conjoint analysis was carried out to estimate a monetary (economic) value of the claimed benefits among senior students of the Saraburi Vocational School and farmers in Thailand. External benefits of the technology of EM include avoidance of the use of antibiotics, pesticides and synthetic fertilizers, reduction of the release of greenhouse gases (methane, nitrous compounds) and no contamination of water sources. The conjoint analysis estimated that there is a perceived environmental benefit valued at 15 US dollars per month per person. If this value is applied to a shrimp farm with 5 family members and a crop cycle of three months, the total external benefits of one crop can reach 225 dollars, based on the local currency and the present exchange rate. This amount is a conservative estimate but it can be consider as an attempt to incorporate the additional benefits of the technology of EM when compared to conventional practices for the development of local and national policy plans and projects.

Keywords: *Externalities, Effective Microorganisms, environmental assessment, conjoint analysis, shrimp production.*

Introduction
Under different circumstances, individuals, households or firms impose costs or benefits on other members of Society, and sometimes these benefits or costs receive no compensation (Edward-Jones, *et al.* 2000; Hanley *et al.* 1997). An externality arises when production or consumption (or other activities) provides to Society an utility to the producer/consumer without paying for costs imposed to other entities, or receives no compensation according to the benefits provided to others (Bromley, 1991; Rao, 2000).
In an analysis of the UK agriculture, Pretty *et al.* (2000) indicate that external costs from the agricultural sector arise from the emissions of nitrous oxide from synthetic fertilizers, the effect of the Creutzfeldt-Jakob (nvCJD) disease and the BSE crisis, emissions of methane from livestock, bacterial and viral outbreak in the food chain and the presence of pesticides in sources of drinking water. On the other hand, environmental services (positive externalities) provided by the agricultural sector include recreation opportunities, enjoyment of landscape, carbon sequestration and nitrogen fixation (Pearce,1993). Pretty *et al* (2000) highlight that it is necessary to estimate the aggregate positive externalities provided by agriculture since this value might even exceed negative externalities in certain farming systems.
Hansen *et al* (2001) stress that organic farming systems have a lower impact to the environment than conventional production systems and could be considered an appropriate agricultural technique. The technology of EM has been taken as an example of an appropriate technique applied into organic farming systems, which environmental benefits should be assessed and valued.

Methodology

The first step to evaluate external benefits is to assess the environmental benefits provided by certain technique compared to current practices. The main problem for the ecological assessment is the "uncertainty" of the effects caused by pollution or its prevention (Pearce, 1993). Thus, it is difficult to predict with a 100% accuracy the damage that a specific pollutant will have in the environment and human health or the benefit of its avoidance. The ecological analysis was prepared based on the scientific reports from the International Conferences on Kyusei Nature Farming.

A second step is the application of a non-market valuation technique to estimate the economic value of the environmental benefits provided by the technique under study (Adams and Kimmage,1998, Russell, 200). For this study the Conjoint Analysis (CA), a variant of the Contingent Valuation Method (Garrod and Willis ,1999; Russell, 2000), was applied to value the willingness to pay (WTP) for environmental improvements due to the application of EM technologies. This analysis was carried out in Thailand among senior students of the Saraburi Vocational School and farmers. They were asked for their values of the perceived benefits of the application of EM technologies based on a 0-4 scale to estimate their WTP. Finally average and standard WTP were calculated and aggregated (Predo *et al*, 1999).

Results and discussion

Environmental assessment

External benefits of the technology of EM include reduction or avoidance of the use agrochemical inputs. The amount of synthetic fertilizers applied under conventional systems can be reduced by the capacity of EM to enhance soil conditions (Paschoal *et al.*1993,1995; Tokeshi *et al.* 1993; Zhao,1995; Frighetto *et al.*1997). Therefore, reducing problems with nutrient run-off and leaching that lead to pollution of water sources (Hansen *et al.* 2001).

The non-use of synthetic fertilizers can also decline the amount of greenhouse gases released to the atmosphere when fermenting waste under anaerobic conditions (Le Khac Quang, 2001) especially nitrous compounds. Ammonia gases in poultry farms have been reduced thanks to the capacity of EM to converts volatile nitrogen principles into fixed forms of nitrogen (Li and Ni, 2000). Also, under on-field conditions the application of EM has reduced methane emissions from paddy fields (Samy *et al,* 1995).

EM can help to reduce the application of synthetic pesticides. This can achieved by the biological control of pathogens by inoculation of antagonist beneficial microorganisms (Castro *et al.* 1993ab; Wingenasantana, 1993; Venegas, 1993; Tokeshi *et al.* 1995; Ramos and Cabezas,1995; Borgen, 1997, 2000; Wood *et al.*1997; Guest, 1997; Shen, 2000; Yamada and Xu, 2000). Nematodes is a good example of a plague efficiently controlled by the application of organic fertilizer inoculated with EM (Tabora *et al.*2001)

An example of the benefits of the application of EM technologies can be illustrated by the case of shrimp farming. Table 1 compares a system of shrimp cultivation under EM management and conventional practices.

Conjoint analysis

To continue with the CA the behaviour of farmers using EM was analysed before applying the CA. For example, Mr Thong Kaen, owner of Chaiyapruek farm (Chachoengsao province, Thailand) has been applying EM for over five years and has experienced the benefits of the application of the technology. He spends around 8 hours a week, training 10-20 farmers as average on the use of the technology. He does not charge the farmers for his time and experiential knowledge, as he believes that the benefits of EM should be spread among farmers to alleviate their current problems. This action kind of actions could be identified as an indicator of his value of environmental benefits of EM.

Table 1. Ecological assessment and comparison of specific variables between EM and conventional system for shrimp production.

Variable	System	
	EM [1]	Conventional
Pond area (ha)	1[1]	1.6[3]
Density (animals/m^2)	35[1]	69[3]
Aeration	Only night time (rain) [2]	All day[2]
Yield (kg/ha)	6501[2]	6731[3]
Time for pond preparation (week)	1[2]	4[5]
Feed conversion ratio[6]	1.2[12]	1.7[3]
Cost of producing 1 kg of shrimp	2.2[1]	3.0[4]
Cost of production per hectare	14302.2	18862.5

Source: [1]Pongdit (2001) [2]Nindum (1997) [3]Patmasiriwat *et al,* 1998 [4]Ling (1997) amount (actualised from 1997 USD) [5]Hambrey and Lin (1998) [6]Feed conversion ratio is the unit weight of feed given, divided by the live weight (or wet weight) of animal produced (New, 1987).

Based on a similar approach as the “willingness to offer” of Mr Thong Kaen, 85 students from the Saraburi Vocational High School were asked for their willingness to take some of his time to educate other people on the application of EM technologies. Again, this is taken as an indicator of their value of the environmental benefits identified for the technology. Then, an opportunity cost was placed on the hours indicated by students based on current incomes of alternative works. The results are presented in Table 2.

Table 2. Willingness of students to offer their time to promote EM among farmers, expressed in US$, September 2001.

	WTO
Hours/day	2.73 ± 0.96
Day/week	3.14 ± 1.25
Hours/month	35.01 ± 18.79
Opportunity cost (US$ hour^{-1})	0.43
Total WTO per month	15 ± 8.08

WTO: Willingness to offer hours to disseminate EM technologies.

There is a monthly estimated value of the environmental benefits of EM of about 15 US$ per person. If this value is applied to a shrimp farm with 5 family members and a crop cycle of three months, the total external benefits of one crop can reach 225 dollars, based on the local currency and the present exchange rate.

To continue with the study of shrimp production the direct benefits of shrimp farming applying EM practices can be combined with its environmental benefits as determined by the CA. The total benefits of the technology thus, include direct economic benefits (i.e. lower costs of production) and indirect benefits (improvement on environmental conditions) that can be “internalized”. Aguilar (2001) estimates that direct benefits of EM technology in the case of shrimp farming can be of 4720 US$ per hectare per crop and the indirect benefits, as perceived by stakeholders, could be of the range of 221 US$ per crop. These numbers can be considered as a low estimate since the CA is based on a cost of opportunity for the agricultural sector and the value is also affected by currency exchange ratios.

This amount is a conservative estimate but it can be consider as an attempt to incorporate the additional benefits of the technology of EM when compared to conventional practices in a Cost Benefit (C/B) analysis. C/B analysis should incorporate environmental impacts expressed in monetary terms to take a more real decision when developing local and national policies, plans and programs. The external benefits of the application of EM are expressed into enhanced levels of environmental quality than conventional farming and thus, should be included into the economic benefits to Society.

Conclusions

The ecological assessment of the application of EM technologies demonstrated the potential of EM to enhance environmental conditions over current production practices. Specific advantages include the reduction of synthetic inputs, no contamination of water sources, reduction in the release of greenhouse gases.

The CA estimated that there are perceived environmental benefits valued at 15 US dollars per month per person. This value can be increased as the technology is spread and more people benefit from the application of the technology. Furthermore, this number is still conservative as the opportunity cost and monetary estimation is affected by alternative sources of incomes and currency exchange rates.

Despite the issues raised above, these numbers attempt to incorporate monetary values into C/B analysis utilized in decision making. Policy, plans and programs at local, regional and national level should incorporate such values into their analysis, since stakeholders and Society as a whole benefit from the application of the EM technologies as described by the ecological assessment.

Acknowledgements

This research was carried out thanks to the support of the EM Research Organization. Special thanks go to Dr. Teruo Higa, President of EMRO for his continuo support and to the staff of the Asian Pacific Natural Agriculture Network for their help to arrange farm visits, interviews and the compilation of information. Also, I acknowledge the logistic support of the Saraburi Training Center. Finally, I would like to thank Dr. Richard Baines and Prof. Paul Davies from the Royal Agricultural College, Cirencester for their advice and comments.

References

Aguilar, F.X. (2001). Ecological assessment and monetary valuation of the benefits of biodigestion and Em technologies. MSc. dissertation, Royal Agricultural College. [Internal document].

Borgen, A. (1997) Effect of seed treatments with EM in control of common bunt (*Tilletia tritici*) in wheat. In Sangakkara U.R. and Senanayake, D. (Editors) Proceedings of the Fifth International Conference on Kyusei Nature Farming. Bangkok, Thailand. 207-215.

Borgen, A. and D. Mehrnaz. (2000) Biological control of common bunt (*Tilletia tritici*). In Hui-lian Xu, J. Parr and H. Umemura.(Editors) Nature Farming and Microbial applications. 157-172.

Bromley, D. (1991). Environment and Economy. Blackwell. 247 pp.

Castro, C.M.; Motta, S.D.; Pereira, D.S.; Akiba, F.; Ribeiro, R.L.D. (1993). Effective Microorganisms for Control of *Xanthomonas campestris* pv *vesicatoria* in sweet pepper. In J.F. Parr, S.B. Hornick and M.E. Simpson (Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 239-241.

Castro, C.M.; Motta, S.D.; Pereira, D.S.; Akiba, F.; Ribeiro, R.L.D. (1993). Potential use of EM for control of phytopathogenic fungi and bacteria. In J.F. Parr, S.B. Hornick and M.E. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 236-238.

Edwards-Jones, G.; Davies, B.; Hussain, S. (2000). Ecological Economics. An Introduction. Blackwell. 266 pp.

Frighetto, R.T.S.; Valarini, P.J.; Tokeshi, H.; Oliveira, D.A. (1997) Action of Effective Microorganisms (EM) on microbial, biochemical and compaction parameters of sustainable soil in Brazil. In Sangakkara U.R. and Senanayake, D. (Editors) Proceedings of the Fifth International Conference on Kyusei Nature Farming. Bangkok, Thailand. 159-164.

Garrod, G.; Willis, K.G. (1999). Economic Valuation of the Environment. Edward Elgar, USA. 384 pp.

Guest, D. (1995). Bokashi (EM) as a bio-control agent to suppress the growth of *Phytophthora cinnamomi*. In Sangakkara U.R. and Senanayake, D. (Editors) Proceedings of the Fifth International Conference on Kyusei Nature Farming. Bangkok, Thailand. 216-218.

Hambrey, J and C. LIN (1998). Shrimp Culture in Thailand . In Readings in Aquaculture Development [online]. Available from http://www.agri-aqua.ait.ac.th/AQUA/readings/JHmexico.html [Accessed 15/10/01].

Hanley, N.; Shogren, J.F.; White, B. (1997) Environmental Economics. Macmillan. 464 pp.
Le Khac Quang. (2001) EM technology application in Vietnam and some results in environment treatment. In Y.D: Senanayake and U.R: Sangakkara (Editors) Proceedings of the Sixth International Conference Kyusei Nature Farming. Pretoria, South Africa. South Africa. [In press].
Li, W.; Ni, Y. (2000). Use of Effective Micro-organisms to suppress malodors of poultry manure. In Parr J.F., Xu, H. and Umemura, H (eds.) Nature Farming and Microbial Applications. 215-223.
Paschoal, A.D. (1997). Quality of oranges in a field under Kyusei Nature Farming and EM technology in Brazil. In J.F. Parr, S.B. Hornick and M.E. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 175-181.
Paschoal, A.D.; Homma, S.K.; M. J., Jorge and M.C.S. Nogueira. (1993) Effect of EM on soil properties and nutrient cycling in a citrus agroecosystem. In J.F. Parr, S.B. Hornick and M.E. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. 203-208.
Paschoal, A.; Homma, S.; Sances, A.B. and M. Nogueira. (1995) Effect of EM on soil quality, fruit quality and yield of orange trees in a Brazilian citrus orchard. In J.F. Parr and S.B. Hornick (Editors) Proceedings of the Fourth International Conference on Kyusei Nature Farming. Saint Jaques, Paris. 103-111.
Patmasiriwat, D.; Kuik, O. and Pednekar, S. 1998. *The Shrimp Aquaculture Sector in Thailand: A Review of Economic, Environmental and Trade Issues.* CREED Working Paper 19.
Pongdit, S. (2001). Results of black tiger prawns rearing with EM technology. Data collected from March to August 2001. Chaiyapruek farm. APNAN [Internal document].
Pearce, D. 1993. Economic values and the natural world. Earthscan Publications. 124 pp.
Predo, C.D.; Briones, N.D.; Francisco, H.A.; Pacardo, E. P. (1999). Non-Market Valuation of the Benefits of Protecting Lake Danao National Park in Ormoc, Philippines. Journal of Environmental Science and Management. 2 (2), 13-32.
Pretty, J.N.; Brett, C.; Gee, D.; Hine, R.E.; Mason, C.F.; Morison, J.; Raven, H.; Rayment, M.D.; Van der Bjil, G. (2000) An assessment of total external costs of UK agriculture. Agricultural Systems 65: 113-136.
Ramos, G.R. and Cabezas, S.E.C. (1995) Effective Microorganisms for Tick Control in cattle. In J.F. Parr and S.B. Hornick (Editors) Proceedings of the Fourth International Conference on Kyusei Nature Farming. Saint Jaques, Paris.174-177.
Rao, P.K. (2000) Sustainable Development. Economics and policy. Blackwell. 393 pp.
Russell, C..S. (2001) Applying Economics to the Environment. Oxford University press. 383 pp.
Samy, J.; X Aviar, A.; Rahman, A.B.; Sharifuddin, H.A.H. (1995) Effect of EM on rice production and methane emissions from paddy fields in Malaysia. In J.F. Parr and S.B. Hornick (Editors) Proceedings of the Fourth International Conference on Kyusei Nature Farming. Saint Jaques, Paris. 208-210.
Shen, D. (2000) Beneficial microorganisms and metabolites derived from agriculture wastes in improving plant health and protection. In Hui-lian Xu, J. Parr and H. Umemura.(Editors) Nature Farming and Microbial applications.349-366
Tabora, P. (2001). Bananas with EM and compatible technologies, and economic consequencies. In Aguilar F.X. (ed.) Seminar on the application of Effective Microorganisms (EM) techniques in organic farming. [on line]. Available from <http://www.royagcol.ac.uk/research/conferences/EM%20 Seminar%20on%20Organic%20farming%20RAC%202001.htm>. [Accessed 5/05/01].
Tokeshi, H.; Lima, M.A.T. and M.J.A. Jorge. (1993) Effect of EM and green manure on soil productivity in Brazil. In J.F. Parr, S.B. Hornick and M.E. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 193-202.
Venegas, S.E.C. and RAMOS, G. (1993). Tick control in cattle with EM. In J. Parr, S Hornick and M. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 247.
Windenasantana, M. (1993). Nature Farming and Integrated Pest management in Indonesia. In J Parr, S. Hornick and M. Simpson.(Editors) Proceedings of the Third International Conference on Kyusei Nature Farming. Santa Barbara California. 174-185.
Winpenny, J.T. (1991) Values for the Environment. Overseas Development Institute. 276 pp.
Wood, M., Miles, R.; Tabora, P. (1997). EM fermented plant extract and EM5 for controlling pickleworm (*Diaphania nitidalis*) in organic cucumber. In Sangakkara U.R. and Senanayake, D. (Editors) Proceedings of the Fifth International Conference on Kyusei Nature Farming. Bangkok, Thailand.
Yamada, K.; Xu, H. (2000). Properties and applications of an organic fertilizer inoculated with Effective Microorganisms. In Xu, H, Parr, J and H. Umemura (Editors) Nature farming and microbial applications. 255-268.
Zhao, Q. (1995). Effect of EM on peanut production and soil fertility in th red soil region of China. In J.F. Parr and S.B. Hornick (Editors) Proceedings of the Fourth International Conference on Kyusei Nature Farming. Saint Jaques, Paris. 99-102.