BIOVILLAGE WORLDWIDE: BUILDING ON MULTIFUNCTIONALITY OF VERMICOMPOST TECHNOLOGY

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Biovillages are emerging as composite eco-technology packages for achieving the UN Millennium Development Goals of reducing poverty, eliminating hunger and sustaining life-support systems of this planet. As part of an evolving forum, Biovillage Worldwide, we have been exploring with colleagues the niche between the technological and institutional horizons of biovillages. We believe that the future of agriculture and rural development will be shaped by the creative utilization of biological inputs, biological agents, biological processes and ecological knowledge. We share here our understanding and reflections on how current experiences of disseminating vermicompost technology can be harnessed for building biovillages across rural Asia.

Vermicomposting represents the growing branch of eco-technologies or green technologies that can enhance agricultural sustainability and secure agro-based livelihoods. Employing earthworms as versatile bioreactors, one can recycle organic wastes, stimulate rejuvenation of degraded land, conserve soil moisture, improve crop yields, and usher in an evergreen organic production system. Integrated with other elements of biovillage software, this can help villagers build and run their own projects aimed at food sovereignty and livelihood security.

Vermicompost Extension in Asia

Vermicompost technology is increasingly occupying an important place in the wider developmental canvas of many organizations in Asia. The extension of vermicompost production methods, today, forms a part of initiatives directed towards sustainable and ecological agriculture, organic production, biodiversity conservation, income generation for the poor, women's economic development, recycling of solid organic waste, rural entrepreneurship development, and so on. Together, these constitute valuable components of biovillage architecture. The following are some examples of such extension initiatives.

Sustainable/Ecological Agriculture

One major platform for vermiculture extension has been the promotion of sustainable and ecological agriculture. The World Bank, for example, is financing the Diversified Agricultural Support Project in Uttar Pradesh and Uttaranchal in India for transition towards environment-friendly agricultural practices such as

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the use of compost, vermicompost, bio-fertilizers, bio-pesticides, and green manure. The Centre for Integrated Rural Development for Asia and the Pacific (CIRDAP) in Dhaka initiated a pilot project entitled "Sustainable Development of Agriculture through Organic Farming using Vermiculture Practices" in Bangladesh, Myanmar, Nepal and Pakistan. In Bangladesh, the Center for Agriculture and Rural Development (CARD) is seeking to develop the worm industry and popularize the use of vermicompost and vermiwash in Bangladesh in view of the proven value of these bio-inputs in soil amelioration and plant growth.

In Nepal, the Nepal Swiss Community Forestry Project (NSCFP) has pilot tested vermicompost technology in the rural remote hills of Dolakha District. The idea has been to achieve better utilization of forest/crop residues, increase yields of agricultural crops, and generate household incomes through sale of earthworms and vermicompost. Verification trials in four sites dealt with four different treatments (vermicompost from broad leaf litter, pine needles, mixed type of litter, different ratio of forest litter and cow dung, etc.). A very fast rate of decomposition (about two months) could be achieved at an altitude of about 2000 masl, whereas normal decomposition period exceeds six months. Not only the quality of vermicompost turned out to be high, the multiplication rate of the earthworms was also fast. The collaborating farmers started selling vermicompost and earthworms, and also planned trials to see the effect of vermicompost on vegetable crops like cauliflower, cabbage, broad-leaf mustard, etc. (Gurung 2004).

Organic Production and Biodiversity Conservation

Supported by UNDP, Sri Lankan NGOs like Podujana Himikam Kamituwa (People's Rights Committee) and Human and Environmental Development Organization (HEDO) are promoting vermiculture as a part of biodiversity conservation and organic production. The PHK is seeking to develop home gardens with vermiculture based composting units for production of organic vegetables. The HEDO, on the other hand, focuses on biodiversity conservation through promotion of sustainable agricultural methods including vermiculture and development of home gardens. Besides raising community awareness, HEDO is also engaged in transfer of vermiculture technology to relevant NGOs in ten districts of Sri Lanka (UNDP 2004).

Gami Seva Sevana Ltd. (Rural Service Centre), based at the village Galaha in the mid-country plantation area of Sri Lanka's Kandy district, has successfully used vermiculture to revive the productive capacities of barren and over 100-year old abandonec tea plantations (at an elevation of about 600 masl). The seven-hectare farm and training centre run by the GSS has become a model for organic agriculture in Sri Lanka. GSS is conserving 124 varieties of rice out of Sri Lanka's 2800 recorded rice varieties along with other seeds. Apart from helping save Sri Lanka's rich bio-diversity, GSS has changed the lives of the local small farmers who now produce high quality products that meet international organic standards. The organic farmers of Galaha prepare vermiwash by putting goat dung, leaves and earthworms in a barrel, with a tap at the bottom. Water is poured into the barrel everyday and it seeps through the layers of wastes and worms. Farmers consider the vermiwash an easy-to-produce and fine fertilizer to which vegetables respond really well (de Silva 1997, Senanayake 2000).

Besides, several other organizations like Friends of Lanka (FOL) at Kegalle, Future in Our Hands Development Fund (FIOH) at Badulla and Centre for Human Development (CfHD) at Kegalle promote sustainable organic farming and environmental conservation activities in Sri Lanka. Intensive training of farmers on simple waste recycling methods by these organizations has led to adoption of vermicompost technology in their project areas.

Income Generation for the Poor

In densely populated, low-income neighborhoods in Indonesia, making vermicompost is a successful method to process organic wastes. A pilot group of about 60 Jakarta families used 30-litre tubs with 0.50 kg earthworms to compost household organic materials. Within two months, a tub produced 20 kg vermicompost that was used by the family or sold locally to supplement household income (Perla 1997). This later graduated into community-based waste recycling initiatives across Indonesia (UNESCO 2004).

In Vietnam, vermiculture (practiced in brick blocks or wooden cases or woven bags) is integrated with small-scale poultry farming. The earthworms, of the species *Perionyx excavatus*, are fed every two days with a mixture of bovine manure and decayed rice straw at 1:1 ratio. The quantity of feed varies according to the number of earthworms raised. The earthworm biomass doubles in about four weeks and is harvested every week to feed chickens (FAO 2004).

In Philippines, vermicomposting emerged as an important strategy to beat down the high cost of fertilizer, recycle farm wastes, and to produce animal and fish feed. The Philippine Council for Aquatic and Marine Research and Development (PCAMRD) has identified vermimeal as an excellent substitute for imported fishmeal used in prawn, fish and animal diets. This has great bearing on the Philippine economy as the country imports huge quantity of fishmeal with a substantial drain on foreign exchange resources (Nicolas 2004).

Women's Economic Development

In the Terai of eastern Uttar Pradesh (India), at the foothills of Nepal Himalayas, the Gorakhpur Environmental Action Group (GEAG) has promoted women's self-help groups (SHGs) not only as institutions for improving their socio-economic status, but also mobilized them as agents of change and advocates for sustainable agriculture. GEAG has consciously developed the capacity of these groups through a "greening" process that equipped them with appropriate, sustainable technologies, conceptually as well as technically. These "greened SHGs" have spearheaded an ecological agriculture movement in the area, promoting LEISA (Low External Input and Sustainable Agriculture) techniques including vermiculture. Establishing a self-sustained, community-owned extension system, the members of these groups have become extension agents of green technologies (Tripathi and Wajih 2003).

Recycling of Solid and Food Wastes

The Bhawalkar Earthworm Research Institute (BERI) at Pune, India has initiated six large-scale vermicomposting projects and motivated over 5000 farmers to use vermicompost. A system implemented by BERI at the Indian Aluminum Company Limited (Indal) site uses worms to treat solid wastes and sewage from a residential colony and to filter the company's canteen waste-water for reuse in the cooling tower. Venkateshwara Hatcheries Limited in Andhra Pradesh (India) also applies BERI vermiculture technology to process almost four tonnes of poultry residues per day. The end product is marketed as "Biogold" at a much higher price than the conventional compost (Hoornweg et al. 1999).

The Maharashtra Agricultural Bioteks in India has devised methods to convert biodegradable industrial wastes, like pulp waste from paper mills and filter cake and liquid effluent from sugar factories into vermicompost. Three facilities are already producing 32 tonnes of vermicompost each month from these wastes, commonly regarded as pollutants (Jambhekar 2003). An Indian company, Orient Vegetexpo Limited, successfully operated a vermiculture facility to digest 4.50 tonnes of onion residues per day during a ten-month processing season. The adsorptive capacities of the earthworms dissipate the smell of onions within a few hours of feeding (White 1996).

The Korean government has prohibited the disposal of food waste in rubbish dumps from 2005. The aim is to promote recycling of food waste and curtail environmental pollution caused by their unsafe disposal. In Korea, about 4.10 million metric tonnes of food waste is produced each year. Of this, only 56.80 percent (2.33 million metric tonnes) is recycled to make compost, livestock feed, and other agricultural inputs. The National Institute of Agricultural Science and Technology in the Republic of Korea has been advocating processing of food waste through earthworms. In this scheme, the effectiveness of vermicomposting is ensured through blending of food waste (with saw dust or rice hull) to dry out excessive water, pre-fermentation to bring the acidity to near neutrality (a p^H of above 6.0), and addition of fresh water to keep the salt content of the foodwaste below 0.50 percent (NIAST 2003).

Indonesian NGO, ECOTON, effectively used vermicompost technology to improve the condition of Surabaya River in East Java that was grossly polluted by industrial and domestic wastes. The local community used the river as a disposal site for their household garbage. Domestic waste, although less toxic, contributed significantly to the reduction of dissolved oxygen, loss of biodiversity, and lowering of water quality in the Surabaya River. The people in the densely populated Driyorejo district were made aware of the need for restoring the environmental quality of their river. Village level training on vermicompost production methods (using the earthworm species *Lumbricus rubellus*) empowered the community with a solution for disposing domestic wastes, while reaping economic and environmental gains in the process (ECOTON 2004).

Agri-entrepreneurship Development

The Morarka Rural Research Foundation (MRRF), with its headquarters in Jaipur, India has been promoting vermicompost for biological fertility management of the soil as well as reducing the production cost. It disseminates the know-how of its surface bed method of vermicomposting, which does not involve construction of pits and is easy to adopt by the farm families. The choice of species includes *Eisenia foetida* for composting farm waste and a poly-culture of *Eisenia foetida* and *Eudrilus eugeniae* for bioprocessing of urban waste. The levels of vermicomposting activities encompass: (a) farmer-level vermicompost production (@ five tonnes per year) that farmers can use on their own farm or sell locally; (b) large-scale vermicomposting by resource-rich farmers (30-40 metric tonnes annual capacity); (c) commercial level vermicompost production by agri-entrepreneurs (100-10,000 metric tonnes/year capacity) and (d) production of vermicompost and bio-pesticides (from cattle urine) from thousands of stray cattle in collaboration with the Municipal Corporation of Delhi and certain cattle shelters (locally called *gaushala*) in Rajasthan (India).

Positioning itself as the world's largest vermicompost producing network, the MRRF delivers bulk quantities of vermicastings, earthworms (*Eisenia foetida*), and enriched vermicompost for probiotic applications in organic agriculture in single lots from various locations in India as per certified organic input specifications. It also offers turnkey solutions for biological fertility management of tea gardens to reduce the cost of cultivation by 20-30 percent (Gupta 2003, Sehgal 2003).

Vermicompost: Multifunctional Attributes

Facilitating completion of the natural recycling loop of agricultural residue and other biodegradable waste is a much-desired objective of biovillage projects. Vermicomposting is considered an important tool for achieving this goal. The following is an account of multifunctional attributes of this technology, an understanding of which would help better integration of worm-based innovations in biovillage settings.

Simplicity and Scale Neutrality: Vermicomposting is easy to practice as an indoor as well as outdoor activity. Both farm and domestic wastes can be put to good use. It can be adopted on a smaller scale on one's own farm or at a commercial scale including large-scale waste recycling units.

Plant Nutrition: Vermicompost contains nitrogen, phosphorus and potash as well as micronutrients (such as B, Cu, Fe, Mn, Mo, Zn, etc.) in sufficient quantities and in available form, besides beneficial microorganisms, microflora, earthworm cocoons, and some growth regulators. As compared to normal soil, vermicompost is five times richer in N, seven times in P, 11 times in K, two times in Mg and Ca, and seven times in actinomycetes (Bansal 2002). However, vermicompost is a complex biofertilizer that must not be treated as a mere supplier of plant nutrients. In fact, the buffering action of vermicasts neutralizes soil p^H, reduces soil toxicity, and makes minerals and trace elements readily available to plants. It also reduces leaching of nutrients, especially of N, from chemical fertilizers.

Cost Reduction and Input Substitution: Available experiences show that not only does vermicompost reduce the cost of crop production but it also enhances output by helping rejuvenate the soil. The farmers' dependence on external inputs such as chemical fertilizers and pesticides is also reduced substantially over a period of time. A cost reduction by 20 percent along with yield improvement by 25 percent has been noticed in Rajasthan, India (Sehgal 2003). Farmers growing grapes, pomegranate and banana in Maharashtra, India reported a 90 percent reduction in the use of chemical fertilizers (Jambhekar 2003). The cost-effectiveness of vermicomposting has been reported in terms of a benefit-cost ratio of 1.40:1.00 with an internal rate of return of over 40 percent (CSRTI n. d.).

Drought Proofing and Erosion control: Vermicompost provides excellent soil structure, porosity, aeration, drainage, and water retention capacity. It helps plants grow stronger and have deeper root systems for better drought tolerance and disease resistance. The mucus coating of vermicasts being hygroscopic in nature absorbs water and improves water-holding capacity. This ability of vermicompost to retain water helps crops survive on less water, signifying a boon for drought-prone areas. The structural stability of vermicompost (measured in terms of the number of raindrops destroying the aggregate structure) worked out to be 849 raindrops as compared to 65 raindrops for normal soil (Meena 2003). Thus, adding vermicompost to soil aids in erosion control.

Wide Applicability: The compost provides beneficial effects on a wide range of crops including cereals, vegetables, horticultural and plantation crops, etc. It is also equally effective over a varied geographical setting ranging from Himalayan range (Dolakha district, Nepal) to the up-country landscape in Sri Lanka to the moisture deficient dryland areas of Rajasthan, India. Earthworms can also be cultured in different organic materials including agricultural residue (husk, straw, farmyard manure, etc.), animal manure, dairy and poultry waste, biogas sludge, food industry waste, kitchen/household waste, leaf litter, weeds, etc. Even the slow-decomposing, high-lignin biomass (like coconut plantation and coir industry waste) can effectively be converted into compost using suitable species of earthworms (Prabhu et al. 1999). Similarly, vermiculture can transform the huge sericulture waste into nutrient-rich compost (CSRTI n.d.).

Efficiency of conversion: The vermicompost production capacity of earthworms can be gauged from the fact that each worm, weighing 0.50 to 1.20 grams, produces an equal quantity of compost in 24 hours. Thus, about 1000 earthworms can churn out about a kilogram of vermicompost a day (Sehgal 2003). Composting through earthworms is completed in 50-60 days while anaerobic composting in pits takes 4-5 months.

Organic input: Vermicompost is a sweet-smelling, fine, granular and stable organic matter. It is lightweight, humus-rich and richer than other types of composts. Importantly, vermicompost is a bio-input that can help farmers capture the growing market for green products and health foods. Regular use of vermicompost as part of an organic farming package leads to good yields. It also enhances quality, shelf life and nutritive value of horticultural crops. Organically grown products fetch a premium price in both domestic and international markets.

Complementary effects: Worms multiply fast. Under optimum conditions eight worms can produce 1500 new worms within six months. The mature worms, high in protein, are often sold as fish bait or used directly to supplement animal feed. The earthworm biomass can also be processed to produce vermimeal for use as a protein-rich livestock and fish feed. Vermicomposting can also be combined with planting live-fences of *Tithonia diversifolia* or *Veronica sublingera*, etc. (as practiced by Sri Lankan farmers). Besides improving soil structure, these plants provide leaves (containing good amount of nitrogen) for making liquid fertilizer (vermiwash) as well as for mulching.

Vermicompost in Biovillages: Implications for Extension

One building block of biovillage architecture is the creation of more avenues for rural farm and non-farm employment based on local needs and marketing opportunities. Biovillages provide new options for earning a living particularly for the smallholders, the resource-poor and the assetless. The tecnological packages may include household mushroom cultivation, floriculture, grassroots seed industry (indigenous and hybrid seeds), coir rope-making, group aquaculture in community ponds, ornamental fish-rearing, rearing small ruminants under stall-fed conditions, dairying, poultry and other high value enterprises. All these exercises are based on micro-level planning, and enterprises supported by micro-credit. The other building block is eco-farming that replaces chemicals and capital with knowledge and biological inputs like vermicompost, bio-fertilizers, bio-pesticides, bio-control agents, etc.; which in turn creates new 'eco-jobs' in the villages.

Although there are designated biovillages, like those set up by the MS Swaminathan Research Foundation at Chennai, India there are many other villages across Asia that have essential features of biovillages. We look forward to the unfolding of this biovillage growth cycle. Some possible measures that would improve vermicompost development in biovillages or help turn a worm-based initiative into a full-grown biovillage are given here.

Creating Earthworm Inventory: Documenting regional native earthworm biodiversity in Community Biodiversity Registers will help in identification of promising species of earthworms suitable for bioprocessing of diverse organic materials. Indigenous wisdom can be a valuable resource for environmental sustainability in rural areas. A study of indigenous ecological knowledge and alternative local uses of earthworms may be useful in their application across the region.

Developing Worm-based Bio-Enterprises: Development of small and micro-enterprises based on earthworms, linked to adequate credit support, has tremendous potential for promotion of rural self-employment. Preparation of a shelf of projects, creation of a supply network and infrastructure (e.g., worm hatcheries), establishing a marketing chain, etc. are some of the operational requirements. For long-term sustainability, it is desirable to integrate such efforts with empowerment of the rural poor through self-help groups and ushering them into an organic production system through a conscious "greening" process.

Creating demonstration effect: A successful commercial venture, based on regenerative principles, can spell a demonstration effect convincing people about the merits of sustainable practices. To be considered as a viable alternative, large-scale vermicompost units must be ecologically and commercially sustainable. Setting up of commercial scale vermicompost production plants, which run on a competitive basis without subsidy, will enhance the credibility factor. Drawing inspiration from Cuban agriculture, consideration may be given to large-scale production of compost through industrial plants utilizing earthworms and other biological converters along with extensive use of green manure crops in agricultural lands. Cuba produced 93,000 tonnes of worm humus through 172 vermicompost centres, spread across the island way back in 1992 (GOI 2001). Such initiatives will be worth emulating in the region.

Establishment of Community Recycling Centres: Community should be recognized as the most important unit for effective resource management. In tune with the Indonesian experience (UNESCO 2004), community waste management initiatives may be taken up for recycling of organic waste from households and local markets. With facilitation by NGOs, appropriate skill transfer and supervision by local committees, these community-based recycling centers would provide economic benefits to the participants.

Multi-level capacity building: Vermicompost technology needs to be convincingly presented as a healthy alternative to chemical-based agriculture. Building awareness about regenerative practices and dissemination of successful experiments will facilitate such transition. Training of farmers, grassroots organizations and extension agencies on vermicompost production methods, and inclusion of the subject in the agricultural education curriculum will help capacity building. Equipping housewives and home gardeners with appropriate skills to produce their own vermicompost from domestic waste can be a very useful intervention. Sensitizing policymakers to the significance of regenerative food production methods will go a long way in carrying forward the gains of the current experiences.

Adherence to quality standards: Establishing appropriate quality norms for vermicompost will ensure consumer satisfaction and thereby continuity of its utilization. Care is needed in separating the organic matter from the waste stream before using as feedstock in order to avoid heavy metal accumulation in earthworm tissue. Combining vermicompost making with thermic processes (high temperature half-digestion) will help eliminate pathogenic microorganisms. Research is needed for improving the keeping quality of vermicompost.

Fine-tuning extension messages: The lessons from the plethora of available experiences can help sharpening the focus of vermicompost technology diffusion. Besides highlighting its plant nutrient value, greater emphasis needs to be placed on other desirable attributes of vermicompost to gain confidence of the farmers. A detailed economic analysis will help in understanding the viability of this technology better.

Development of effective extension materials: For speedy dissemination of this important technology, a variety of extension and communication aids may be produced. Efforts are also needed to develop packages of IT-based user-friendly materials to support easy access to relevant information.

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