⌘ Back to Basics: A Multidisciplinary Approach to Organic Living and Waste Management,
Jogamaya Devi College Interdisciplinary Volume 3 (2022), pp. 75-90

The Art of 'Organic' Living: Lessons from Apatani Women in Ziro Valley of Arunachal Pradesh in Northeast India

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Abstract: *The Apatani of Ziro valley, Arunachal Pradesh, stand out as an indigenous community of settled agriculturists in the ecocultural landscapes of the Eastern Himalaya. Their biocultural heritage is an ingenious hill farming system of fish cultivation in paddy fields, integrated animal husbandry and with social forestry. This progressive hill farming system produces two staples in one agricultural plot to accomplish balanced diet at the source itself. This is economically viable and ecologically sound. This advanced 'organic' farming system sustainably uses, manages and conserves local resources to balance agriculture and the biodiversity underlying the functioning of the food production system. Their 'green' and 'clean' agricultural practices promote harmonious coexistence of people and their environment. Like other tribes of Northeast India, the Apatani people are poised at the crossroads of tradition and modernity. Both men and women are involved in the traditional rice-fish farming. However, like other patriarchal milieus, these women are excluded from the decision-making process. The world's tribal and rural women often engage in multiple livelihood strategies, and along with their domestic chores silently perform monotonous agricultural work which necessitates insight into local plant resources, and the Apatani women are no exception to this. This is an endeavour to relook at the Apatani agricultural heritage as a model green farming system that promotes organic living, and focuses on the 'silent' role played by these women with their knowledge-based innovations in an attempt to understand their contributions in advancing solutions to the critical global issue of ensuring food and nutritional security while protecting the environment.*

Keywords:
Agricultural heritage, Apatani, ecological sustainability, traditional knowledge, women

1. Introduction

The term 'sustainability' implies a compromise between the human aspiration for a better quality of life on the one hand, and the limits of nature on the other hand (Kuhlman & Farrington 2010). During the course of its long history from the Neolithic revolution to the scientific and industrial revolution and beyond, agriculture emerged among nomadic hunting-gatherings and evolved throughout with the innovation of shifting cultivation and sedentary farming, to culminate into intensive agriculture. The human concern for preserving natural resources for posterity is a perennial one. In the hunting-gathering stage, the worry was about annihilation of game. In the agrarian phase the anxiety was of losing soil fertility. In the industrial age the apprehension is of environmental holocaust. Early cultures, nearly 12,000 years ago, domesticated plants and animals to ensure a reliable food production system that

buttressed the growth of the early cities and civilization. The Colombian exchange, about 500 years ago, triggered the globalization of plants and animals. The industrialization of agricultural production in the last 300 years allowed the skyrocketing of human population. However, intensification of food production and poverty elevation are linked (Mozumdar 2012). The turbulent first half of the last century trigged a technological response in the form of the so-called 'green' revolution in its second half. Food grain yields doubled in only 40 years for the first time in history (Khush 2001). However, this also drastically altered traditional farming practices at a global scale within a span of only a few decades (Shiva 1991). Soon, the ambivalence so typical of technology manifested itself with undesirable ecological, and even social consequences (Pingali 2012). The bumper harvests from high-input monocultures that relied on high-cost, energy-inefficient and more-polluting external resources such as modern crop varieties, intensive irrigation, farm mechanization and agrochemicals were deleterious to the health of humans and the environment (Evenson & Gollen 2003). Today, the global food production system faces the dual challenge of meeting the food and nutritional security for an ever-growing world population on one hand, and maintaining the productive health of the ever-shrinking global agroecosystems on the other hand. In this century, the effort was to reverse this trend and grow food through biodiverse farming with minimum use of irrigation, farm machinery, mineral fertilizers, and synthetic chemicals. These sustainable agricultural practices adopted alternatives as low-input polycultures with low-cost, energy-efficient and less-polluting local resources to provide greater resilience in the face of economic, environmental and social challenges (Jackson et al. 2007). The need for replacing high-risk 'dirty' technologies with low-risk 'clean' technologies has led to the adoption and diffusion of 'green' agricultural practices as the emerging trend in global agriculture (Rogers 1983). The 'green' technology is an umbrella term for environment-friendly practical solutions from production to usage of a product, that promotes economic development as well as ensures the long-term health of people and the environment. 'Organic' farming has been defined in multiple ways, and in essence refers to a self-reliant agricultural production system that relies more on management of the wider ecosystem itself, rather than outside support. Traditional societies, unlike modern ones, relate to nature in terms of custodianship (Verschuuren et al. 2010). Their resource management practices have been well-documented worldwide among diverse cultures and environments (Berkes 1999; Berkes et al. 2000). Traditional agricultural systems have co-evolved with local natural and cultural systems, exhibiting social and ecological rationale manifested in their traditional knowledge-based sustainable resources utilization practices. These, as an intermediate between hunting-gathering traditions providing local subsistence, and modern farming technologies supporting global mass-production, have achieved the critical balance between exploitation and conservation of natural resources (Jeeva et al. 2006). Reviving them would be the true 'green' revolution that would restore this harmony of agroecosystems with ecological principles that underlie all food production systems. This art of 'organic' living among the world's traditional communities are model food production systems that, in the context of inter-generational equity, espouses care for the environment not only because of its intrinsic value, but also in to preserve the assets for future generations. Gender roles in

traditional and modern agriculture is a recurrent theme of study as these shed light on the role of women in agrarian and even industrial societies. Women, the most important workforce engaged in exhausting tasks, form the backbone of global agriculture. Dictated by social norms to manage daily domestic chores as daughters, wives and mothers, they also pursue multiple livelihood strategies as farmers, gardeners, herbalists, plant gatherers, plant breeders, seed custodians to manage local plant resources as food and medicine to ensure the wellbeing of their family. However, in rural settings, their hard work and key role as producer of food, earner in household economy, and custodian of intangible cultural heritage, remain largely unacknowledged by society at large. Furthermore, despite their key services, customary laws limit their participation in decision-making processes at home, and in the field, plantations and marketplaces, thus increasing the level of inequality vis-à-vis their partners. However, empowered women farmers are in the best position to lead their communities in the conservation, even revival, of the traditional sustainable 'green' practices of their 'organic' farming heritage.

2. Apatani People of Ziro Valley

Northeast India with its incredible blend of diverse ethnicities, is home to small and diverse ethnic groups with distinctive historical, geographical, cultural and social attributes (Ali & Das 2003). The Apatani people are native to the secluded Ziro valley (22°34'N, 88°24'E) in Lower Subansiri district of Arunachal Pradesh in North-east India. This miniscule (1,058 km^2) hilly terrain (1,524 – 2,738 m) is hidden in the sub-tropical ranges of Eastern Himalaya – a part of the Himalaya Biodiversity Hotspot. Although they belong to the Tani tribal group of central Arunachal Pradesh, the Apatani language, beliefs and customs are distinct from all the others. They belong to the Mongoloid stock (Goswami & Das 1990) and speak a Tibeto-Burmese dialect of the Tani language group (Post & Kanno 2013). They (traditionally) adhere to the shamanistic Tani religion called Donyi-Polo (Blackburn 2010). Their 60,000 population is largely concentrated in seven traditional villages (*lemba*), and their satellite hamlets, as well as increasingly in the towns of Hapoli and Old Zirolocated at the two ends of the Ziro valley (Kani 2012). They are endogamous, and socially organized into 78 exogamous clans (*Halu*) and sub-clans (*Tulu*) among them (Blackburn 2010). The tribal council (*buliang*) comprising of clan elders dispenses their traditional self-governance (Elwin 1988). The Apatani people are the custodians of a rich intangible cultural heritage which profoundly reflects their close relationship with their physical environment (Chaudhuri & Chaudhuri 2016). Like the myriad other tribes of India's Northeast, this indigenous micro-culture is now poised at the crossroads of tradition and modernity.

3. Agricultural Heritage of the Apatani People

The traditional agriculture of the indigenous communities in Northeast India ranges from shifting to sedentary agriculture (Majumder et al.2011). This region, with climatic and ethnic diversity, harbours genetic resource in Asian rice (*Oryza sativa*) as local staple. Unlike the

slash-and-burn (*jhum*) cultivation of their neighbours (Karthik et al.2009), the Apatani people are settled agriculturists whose cultural landscape confirms to the paradigm of harmony between nature and humans. Their agroecosystems are extensive terraced rice fields (33 km^2) surrounded by forested mountains (288 km^2), drained by Kale and its tributaries (Rai 2005). Based on their traditional agroecology moulded by their environment, the Apatani people have adopted a plethora of 'green' practices to sustain their rich but fragile agroecosystems along with its biodiversity, to support their traditional way of life. This 'organic' lifestyle is in tune with the now popular idea: reduce, reuse and recycle. The centrepiece of their agricultural heritage is the sedentary farming perfected over centuries in the form of paddy-cum-fish cultivation, linked with animal husbandry and social forestry, to form a 'circular' economy. This exemplifies a highly diverse, well-integrated and noticeably advanced indigenous farming system. Among the disparate methods of fish farming practiced in ubiquitous rice agroecosystems of Northeast India, the Apatani people are the best exponents of mountain valley rice-fish farming (Das 2002). Their *jebi-aji* agriculture, an integrated farming system, concurrently farms rice and fish in the same plot. On the terraced slopes (Figure 1a), native cultivars of japonica rice (*O. sativa* var. *japonica*) or *pyapin* (Dollo et al. 2009) are grown with the exotic common carp (*Cyprinus carpio*) or *aji-ngiyi*, in the plots (*aji*), and finger millet (*Eleusine coracana*) or *sarse* on earthen bunds (*agher*) separating them. Other exotic and native fish-species are also stocked (Nimachow et al. 2010). Farming the primary crop (rice) along with a secondary crop (fish), and even a tertiary crop (millet), is not only an economically viable (Rahman et al. 2012), but also an ecologically sound (Noorhosseini-Niyaki & Bagherzadeh-Lakani 2013) practice. Along with these cereals, a host of other native food crops and wild edibles adds up to an amazing agrobiodiverity (Sundriyal & Dollo 2013). These terraced paddy fields are also the natural habitats of indigenous hill-stream fishes (Nimachow et al. 2010). Their animal husbandry consisting of rearing livestock, including *mithun* (*Bos frontalis*), a semi-domesticated regional bovine of cultural significance (Rai 2005). Their social forestry is centred on bamboo plantations and pine groves (Rechlin & Varuni 2006).

4. Apatani Women as 'Organic' Farmers

The Apatani women traditionally have distinctive nose plugs and face tattoos, a tradition of 'uglification' to save themselves from abduction in the past (Bharadwaj & Boruah 2020). In Apatani society, monogamy is a rule (Kani 2012). The social order is patriarchal, patrilocal and patrilineal, and inheritance rule is primogeniture (Hazarika 2011). The tribal council elders are all men (Elwin 1988). Therefore, women in general, are marginalized and silenced across their social, legal and administrative spheres. Ursula (1953) first reported the role of Apatani women in agriculture and crafts. Haimendrof (1962) documented their hard work in doing monotonous farm jobs alongside daily domestic chores. These women follow a traditional agricultural calendar for maintaining optimum agricultural productivity (Dutta 2015). Each farming activity is linked with festivals in their natural and social settings. The male tribal council administers the integration of land units and utilization of limited

resources of the Ziro valley (Rai 2005). Traditionally, women work alongside men in the fields, gardens and plantations (Kani 1993). However, with distinct gender roles, women till, sow, transplant and harvest the crops, as well as maintain and repair bunds, trails, fences and drains, (Figures 1b-d). All daily and seasonal agricultural activities involve communal labour of traditional farmer groups called *patangajing* (Dollo et al. 2009). Although administered by the male tribal council, women are key members of all these groups. They lead the farm work in the rice terraces, except those operating in the forested periphery. Overlooked in most studies on this agricultural heritage is the pivotal role of the Apatani women. These women farmers, intimately interacting with their environment as part of their daily work, not only hold traditional ecological knowledge (Yamang & Singh 2021), but also transmit them across generations. The oral tradition of the Apatani people is the *miji-migung* (Blackburn 2010). The *miji* represents complex ritually chanted verses of male shaman priests (*Nyibu*) during agrarian festivals to communicate with the 'spirit' world of ancestors for wise council in determining the agricultural almanac. Possibly, their shamanic state of trance involves access and retrieval of cultural memory from the subconscious mind for the practical purposes of social coordination in pre-scientific cultures (Joralemon 2001). However, these further exclude women from decision making in agricultural activities. In contrast, the *migung* consists of myths, legends and tales about the origin of crops, livestock and human social order, spoken in ordinary conversational prose as part of daily activities, usually narrated by grandmothers, mothers and older siblings to the youngsters to assume the didactic function of cultural transmission of traditional knowledge, including those related to agriculture, in this pre-modern society with no traditional writing system in the past (Bouchery 2016). In their myths, Ayo Diilyang Diibu the first wife of Abotani, the forebear of humankind, is the ideal women and an epitome of hard work bringing bountiful harvests. It is a belief that women who follow her footsteps would never face starvation (Dinsu 2018). One story about Abotani's devious second wife Tiinii Rungya reveals her indolence. Pretending to work hard in the rice paddy she demands bamboo tools for weeding, but keeps them idle. Soon, the rice field turn into a grassy wasteland. There was no grain left even for planting the next crop. Therefore, in their unique agricultural heritage, men may decide when to work, but it is the women as informal educators who infuse how to work. These women as 'organic' farmers play a vital role in agricultural operations as a bulk of the workforce, often as leaders, and this is well-integrated with their practical knowhow of local plant and other resources. All round the year, on a rotational basis, women farmers as workers or leaders are singlehandedly involved in ingenious approaches to the management of agronomic resources such as land, water, nutrient and forests, as well as innovative solutions to agronomic problems such as weed and pest infestations, using their 'clean' and 'green' solutions. The following sections highlight the 'green' technology of these women as 'organic' farmers, with the details of their traditional knowledge-based management practices in these agroecosystems to sustain their indigenous food production system along with the substructure of the local biodiversity.

Figure 1: Rhizipisciculture of Apatanis women in Ziro valley, Arunachal Pradesh. **(*a*)** View of the agroecosystems in May. **(*b*)** Rice transplantation in May. **(*c*)** Rice harvesting in October. **(*d*)** Rice threshing in October.

4.1. Land Management Practices

The Ziro valley is a mosaic of settlements (*ude*) among human-modified and natural habitats. The key to the successful agriculture by Apatani women is their diversified land-usage pattern (Dollo et al. 2009) that links rice terraces (*aji-ager*) with houses (*ude*), gardens (*ballu* and *yollu*), pastures (*polang*), pig pens (*alyigiiri*), granaries (*nesu*), burial grounds (*nendunenchang*), plantations (*bije* and *sansung*), forests (*moorey* and *myodi*) and sacred groves (*ranthii* and *sarosan*). Integrated rice-fish farming allows optimal use of limited land resources (Frei & Becker 2005). Paddy fields, as agriculturally-managed lentic wetlands, can be used for fish culture under wet conditions, although these are not primarily designed for fish farming (Halwart & Gupta 2004). The agroecosystem of Apatani women perfectly blends wet rice farming with aquaculture with four physical modifications that favour pisciculture: raised bund height to retains more water, fish pits provide refuge in dry conditions, drainage system controls water level, and fish screens prevent their escape. The terraces are levelled and small (250 to 3,000 m^2) plots are separated by high (0.2 to 0.5 m) earthen bunds fortified with bamboo, cane or timber chips from their plantations. The ideal levelling of plots and presence of bunds reduce soil erosion. The finger millet on the bunds

fortifies them, functions as soil binder, and prevents soil erosion. Weeds such as *Houttuynia cordata* or *siya-haman***,** are not weeded out on the bunds and performs the same function. The contiguous natural woodlands and human-made plantations also check soil erosion (Rechlin & Varuni 2006). The bunds are repaired at the beginning of the farming season (late January), marked by the Murung festival as a fertility rite. The *aji-lenda* farmers group often led by a woman entitled *lenda-kagenee*, constructs and repairs bunds. In plots near forests, crops are protected from wildlife damage with fencing (*narung*) made with bamboo, cane and timber from their plantations. This is done after the farming season (late November). Women of the *sulu-sikhii* farmer group build and mend fencings. In February, rice and millet seedlings are raised in nurseries (*miding*) in the most fertile plots. *Huta*, a wooded trowel is used. The *tanser-patang* farmer group led by a woman *patang-ahtoh* prepares seed beds and sows seeds stored by women as expert seed collectors from their previous harvest. In March, paddy fields are levelled and prepared, denoted by the Myoko festival celebrating kinship. Each paddy field has a small (25 – 35 cm deep) trench as fish pit (*siikho*). The *konchi-patang* farmer group led by a woman *patang-ahtoh* prepares the fields. *Sampeyee*, a wooden shovel is used. In April, rice transplantations begin and fingerlings raised in spawn ponds (*ngyi super*) are first released into the pits. The *halying-patang* farmer group led by a woman *patang-ahtoh* transplants rice in the plots (Figure 1b). Holes are made for planting rice in the plots with *kdu*, a wooden stick with metal tip, and millet on the bunds with *dum*, another wooden stick with sharp tip. During monsoons, the fish moves into waterlogged fields and feeds on the naturally available food and nutrients of this wetland ecosystem. No additional feeding is done. The water is drained out during fish harvest after two-three months. *Takhung*, a funnel-like bamboo trap ensnares the fishing at water outlets. The remaining fish retreats into the pits where they are caught with *tajer*, aconical bamboo net. Sometimes fish is also captured in paddy field itself with *barju*, a basket-like bamboo net, or *ngiyi-pakhe*, a tray-like bamboo trap. The harvested fish is transported live to the market in *ajii-piiwa*, a finely-woven, conical basket made of bamboo or cane. The Apatani women successfully manage their diverse farmlands with early and late ripening rice landraces (Dollo et al. 2009). Early-maturing low-yielding ones e.g., *Ahreh Emmo* are grown in remote plots facing greater risk of wildlife intrusion, inferior fertility and poor irrigation. These are harvested in July. Late-maturing better-yielding ones e.g., *Hatii Emmo* are planted in nearby plots with favourable conditions. These are harvested in October. Terraces with early-maturing rice produce only one fish harvest, while late-maturing ones allow up to three. The rice fields are classified and managed based on water retention capacity of the soil. The *jebi* has clayey soil and high water-retention capacity compared to *ditor* with sandy soil. In the soft field, less fish is stocked than the hard ones to reduce risk of damage to the paddy. Crops such as millets and maize are also cultivated in drier uphill plots (*yaapyo*). In July, the principal agricultural festival of *Dree* is celebrated with rituals for plentiful harvest. The *enthee-patang* farmer group often led by a woman *patang-ahtoh* harvests the crop (Figure 1c), followed by *in situ* threshing (Figure 1d) and transfer to granaries. *Taggi*, a small metal sickle, is used to harvest rice, millet and maize. *Yapyo*, a large tray, is used for winnowing the grains. This rhizipisciculture is a model food production system for developing societies with the

simultaneous production of low-cost plant carbohydrate and animal protein in an agricultural plot to accomplish a balanced staple at the source itself. Therefore, with these ingenious 'green' practices, the Apatani women efficiently manage their limited land-resources of their agroecosystems.

4.2. Water Management Practices

In the Ziro valley, like indigenous farming systems of other tribal communities of northeast India, wet rice cultivation is essentially rain-fed. Integrating rice and fish culture allows optimal use of the water resources as well (Frei & Becker 2005). The rhizipisciculture of the Apatani women involves careful management of the seasonally-available rainwater. Paddy fields are classified as *jebi*, *aane* and *ditor* depending on the increasing need for irrigation (Rai 2005). Kiiley and its tributaries provide limited water supply for irrigation. The rice terraces receive enough water through a complex system of rainwater harvesting and its efficient management. Each rain-fed stream (*kley*) in the adjoining forests is channelized into a series of irrigation canals running along the edges of the valley. Each terrace level receives enough water supply through a network of carefully designed primary channels (*siikho*), secondary channels (*pakho*) and tertiary channels (*hehte*). In each rice field, continuous inflow of water from an earthen feeder channel (*siigang*) takes place through wooden or bamboo pipes (*hubur*). The continuous outflow of excess water from higher to lower terraces involves a ditch (*muhgo*) with a similar pipe. All water inlets and outlets are blocked with bamboo screens to prevent fish escape. Blocking or reopening a connecting pipe with mud and grass allows draining and flooding of plots at a desirable depth. During transplantation, 1-2 cm water level is maintained. This is later gradually raised to about 15 cm. This ensures inundation of rice fields, especially for late ripening rice varieties. Paddy fields are drained during weeding cycles and harvesting. Bamboo fences and plantations along the embankments of canals and streams hold the soil together. Pegs and pebbles are placed in the earthen channels of canals as energy dissipaters. Soil binding reeds such as *Phragmites karka* or *pepu* is grown on these beds. These traditional measures control soil erosion. During the long fallow season centred on December, the *jebi* plots are kept dry but the *diter* plots are kept inundated. The canals and trenches are also repaired along with the bunds before the farming season (late January). The women in the *bogo* farmers group are engaged in constructing and repairing the irrigation works. In August, the peak season for rice cultivation, the women perform the *Yapung* ritual for adequate rainfall. Therefore, these innovative 'green' practices of the Apatani women ensure efficient management of the limited water resources available in their agroecosystems.

4.3. Nutrient Management Practices

The agroecosystems of the Ziro valley, like any other wet rice farming system in the world, suffer from nutrient washout. However, the Apatani women farmers maintain soil fertility by 'organic' means only, and that essentially includes recycling of natural nutrient and waste.

Integrated rice-fish farming improves soil fertility through nutrient recycling (Frei & Becker 2005). The fish plays a key role. They feed on soil detritus, planktons, periphytons, benthos and other aquatic biota of paddy-fields. These habitats in Arunachal Pradesh are conducive for plankton growth (Saikia & Das 2008). Fish excreta added to the soil is an organic fertilizer. The feeding activities of the common carp, a benthic feeder, loosens the soil to increasing dissolved oxygen that accelerates microbial activity at the water-soil interface and improves mineral availability for the crop (Giap et al. 2005). In comparison to rice monocultures, integrated rice-fish farming exhibits higher mineral content of the soil and faster plant biomass accumulation (Duanfu et al.1995). The paddy fields also receive natural nutrient washout from the surrounding hills. Houses and granaries built on higher elevations supply decayed and decomposed waste drained out to the fields below. *Azolla,* an aquatic fern capable of nitrogen fixation, grow in water-logged paddy fields as biofertilizer. The Himalayan alder (*Alnus nepalensis*) or *rwme***,** a non-leguminous tree capable of nitrogen fixation, is planted as agroforestry to enrich the soil (Rai 2005). Panicle harvesting is practiced. Threshing is done in the field. Local rice cultivars are tall with high straw yield. These agricultural wastes are left to decay in the fallow fields. During land preparation, decomposed straw (*liisii*) is added to enrich the soil. Undecomposed materials are incinerated on dry terraces and the ash (*muyuo*) fertilizes the soil. The Apatani women also integrate rice-fish farming with animal husbandry (Rai 2005) and social forestry (Rechlin & Varuni 2006). All local organic wastes are recycled to replenish the humus in the farm soil. The women dump household waste as well as rice chaff (*piinang*), firewood ash (*mubu*), pig excreta (*alyi-ekha*), poultry droppings (*paropai*), cow dung (*sii-ekha*), weeds (*tamih*) and leaf litter (*ankho*) into the rice fields near the villages during fallow season for replenishing the soil fertility. After harvest, cattle graze on the terraces and their dung gets naturally recycled. This fallow season itself also help to regain the depleted soil nutrients. Plant biomass is recycled into compost by traditional method of dumping and covering with a thin layer of soil for decomposition. Measures taken to control soil erosion help conserve soil fertility. The choice of the rice cultivars depends on nutrient status of the soil. In March, the *Myokung* ritual is performed for soil fertility. Thus, these novel 'green' approaches of the Apatani women, include recycling household and farm wastes, help them successfully manage, by organic means, the soil fertility of the agroecosystems.

4.4. Weed Management Practices

The agroecosystems of the Ziro valley, like any other paddy farming system, face the problem of weed infestation. Weed management below the threshold level in agroecosystems is important for sustaining productivity (Singh et al. 1996). Nutrient-rich paddy fields are easily infested with algae and herbaceous weeds that compete with the crop for light, water and nutrients. Commonly weeds in the upland paddy fields of northeast India are *Echinochloa crus-galli* subsp. *crus-galli* and *Cyperus iria* (Chanu et al. 2010). The Apatani women employ only 'organic' means for weed management. The *konchi-patang* farmer group led by a woman *patang-ahtoh* is engaged in weeding (*ahru-hodo*) the paddy fields.

Kele, a long-handled bamboo hoe with sharp metal tip is used for weeding during tillering (May-June) and flowering (September). The short metal-tip *pale* is used in gardens. Surplus free-floating aquatic weeds such as *Azolla* are fished out. Manual weeding loosening the soil to causes water turbidity detrimental to fish growth. These women farmers avoid this problem by draining their paddy fields during weeding and the fish retreats into the refuge pits. Paddy fields biodiversity helps in the biological control of weeds (Hajek 2004). Finger millet growing on the bunds suppresses weeds. Fish farming is now an important element of integrated weed and pest management in rice monocultures (Berg 2002). Water-depth in paddy fields stocked with fish inhibits the growth of paddy field weeds in general (Manna et al. 1969). Microphytophagous (algivorous) and macrophytophagous (herbivorous) fish control algae and weeds in the paddy fields (Piepho & Alkamper 1991). The common carp is an opportunistic omnivore in the paddy fields. While foraging on benthic organisms, it incidentally feeds on epiphytic algae (Saikia & Das 2008) and roots, buds, leaves and stems of weeds (Piepho & Alkamper 1991). As bottom feeders they also indirectly reduce weeds by uprooting plants, making the water turbid for photosynthesis (Moody 1992) and devouring seeds (Chapman & Fernando 1994). Hence, these inimitable 'green' practices of the Apatani women allow efficacious management, by organic means, of weed infestation in their agroecosystems.

4.5. Pest Management Practices

The agroecosystems of the Ziro valley, like the other rice farming systems in the world, also face the problems of pests and pathogens. The Apatani women farmers again cope with this by 'organic' means only. The fish again plays a key role. The common carp feeds on numerous potential rice pests like zooplanktons, zoobenthos and small aquatic fauna such as molluscs and insects (Saikia & Das 2008). The efficacy of fish as a biocontrol agent of pests depends on their position in this habitat. In flooded paddy fields, if the fish pit as not more than 10% of the area, the common carp frequents the rice plants rather than their refuge (Halwart et al. 1996). This carp is the best-known biocontrol agent of the golden apple snail (*Pomacea canaliculata*), a polyphagous herbivore that attacks rice plants across Asia (Teo 2006). The diet of this benthophagic fish in paddy fields significantly comprises of molluscs (Ardiwinata 1957). It predates on juvenile snails which are small enough to fit into the opening between their pharyngeal teeth, crushes the shell, ejects shell fragments, and consumes the flesh (Halwart et al. 2014). This carp is also useful against insect pests of rice such as plant hoppers, stem borers and leaf folders (Yuan 1992). The fish predates on the neonate larvae which, after hatching, often suspend themselves from the rice leaves. Indirectly, the fish also feeds upon aquatic weeds in paddy fields which act as hosts for rice pests. Halwart (1994) concludes that the presence of fish in flooded paddy fields reinforces the natural, well-balanced pest-predator interactions in the natural ecosystem. Rice ear-head bug (*Leptocorisa oratorius*) is a common rice pest in northeast India (Chanu et al. 2010). This is ingenuously managed by the Apatani women by fixing short wooden or bamboo sticks in the paddy fields with impaled frogs, crabs or salted fish captured from the rice paddy

itself, to distract the adult bugs away from the crop (Singh & Bag 2002). Furthermore, the common carp is known to reduce anopheline (*Anopheles* spp.) and culicine (*Culex* spp.) larval populations (Halwart& Gupta 2004). Fish, in general, can also indirectly reduce incidence of fungal diseases by aerating the soil and accelerating the decomposition of organic remains. The common carp strips diseased leaves near the base of the rice plants that are sources of fungal inocula. This also improves air and light availability making the microclimate unfavourable for fungal growth (Guang-Ang 1995). In April, the *Tamu* ritual, and in July, ritualsof the *Dree* festival, are done to protect crops from pests. Therefore, again with the help of these pioneering 'green' practices, the Apatani women commendably manage, by organic means, pest influx in their agroecosystems.

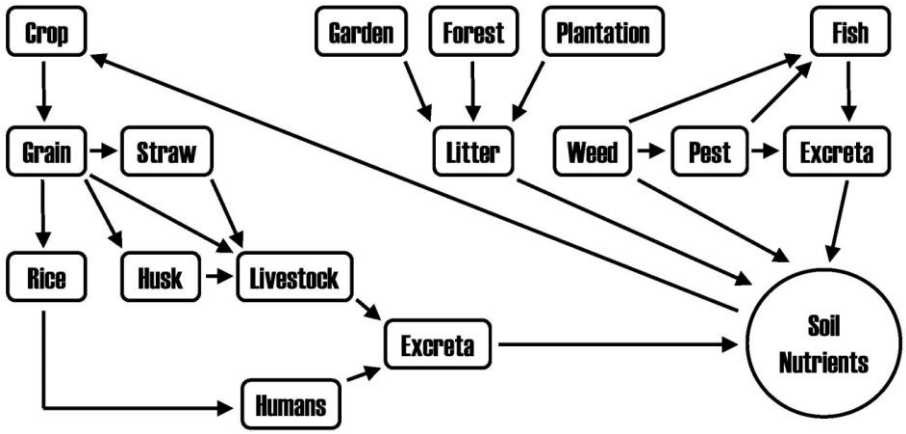

Figure 2: Resource recycling system in the organic farming model of the Apatani women in Ziro valley, Arunachal Pradesh.

5. Conclusion

The intangible cultural heritage of the less technologically-advanced communities, are shaped by their natural environment. Their reverence for nature, entrenched in their way of life, permeates into every facet of their language, culture and wisdom. In traditional agriculture, the environmental stewardship of autochthonous societies is reflected in their beliefs and practices, knowledge and skills, aiming at the conservation of bioresources and biodiversity in natural and modified ecosystems as the foundation of their food production systems. These subaltern cultures emphasize upon harmony, rather than subjugation, in defining their relation with nature. Today, biodiversity of agroecosystems is receiving global attention due to the role in its functioning. This agrobiodiversity is becoming increasingly endangered by changing farming practices with the shift to monocultures, modern cultivars, intensive irrigation, farm mechanization, toxic agrochemicals, and destruction of natural refuges. There is growing global awareness about adopting the 'green'practices of 'organic' farming that puts greater reliance on ecological goods and services for sustainable food production, and less damage to the environment, biodiversity and human health. The Apatani women farmers of northeast India, with traditional knowledge-based management practices based on biodiversity, as well as lore and beliefs that underlie them, are a good example of a traditional

agricultural society practicing environment-friendly strategies to ensure food, heath and livelihood security for the community. This enviable 'art' of organic living of these marginalized and silenced women engaged in rice-fish farming is a model system for promoting the idea of 'green' biodiversity-based agricultural practices elsewhere. These women shun 'dirty' external modern inputs to espouse 'clean' local traditional inputs from their limited natural resources through the sustainable use, management and conservation of their agricultural resources, and effective management of problems in agriculture. Agricultural inputs are minimal, with no profligacy. These are inexpensive, safe and easily-available. No monoculture is practiced. Polyculture is the rule. No modern cultivars are used. Local landraces are nurtured. No farm machinery is used. All agricultural operations are manually performed with indigenous tools and implements. Even draught animals are not employed. Human labour is a major input. No agrochemicals such as inorganic fertilizers, synthetic algicides, fungicides, herbicides, insecticides or molluscicides are used. Compost, biofertilizers and green manure are used to manage soil fertility in their fallow agriculture. Biological control is employed to manage incidence of weeds and pests. Nothing goes to waste. Everything gets recycled (Figure 2). These women with multiple livelihoods as farmers, homemakers, gardeners, planters, foresters, fully explore all the three key features of 'green' technology, viz. reduce, reuse and recycle, in their 'organic' farming. From the Apatani women, the 'daughters of the soil' in a neglected corner of the biodiversity-rich Eastern Himalaya, the key lessons draw from their economically viable, ecologically bearable, socially equitable food production system are about insightful and engaging ways and means of living in harmony with nature and sparingly, but diligently, using her assets to promote economic development without compromising on environmental protection and public health.

ACKNOWLEDGEMENTS

We thank Mr. Christopher Tajo and Mr. Nada Paul for help as local guides and interpreters during visits to the Ziro Valley in May and October, 2014.

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