Prong 1- Revival of Traditional Ecological Knowledge Based Farming Systems: Traditional knowledge through the lens of modern scientific research

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With **Nirmala Sitharaman,** (currently Minister of Finance, GoI) mentioning 'Zero Budget Natural Farming' (ZBNF) in the Budget 2019, our post on Prong 1 of the means of promoting Sustainable Seed Innovations in India is right on time! ZBNF is currently practiced in many parts of India and is known under various names including Suresh Palekar's **Zero Budget Spiritual Farming** (SPNF), **Sri Sri Natural Farming** (SSNF), or just **Natural Farming** (attributed to Masanobu Fukuoka – A Japanese Farmer (1913-2008)). Our post below highlights how some of the key components (products and processes) and insights of Zero Budget Natural Farming as practiced in India, whose principles are sourced, in significant part from ancient Indian such as *Vrikshayurveda* and *Krishi Paraashar*, are increasingly confirmed by modern science. We hope that this post will generate interest (and healthy debate) among academics engaged with agriculture, traditional knowledge, plant breeding and soil sciences.

From the perspective of intellectual property rights that this blog, as well as **this (SSI 2.0) research**, are closely connected, it is noteworthy that neither traditional knowledge per se nor farmers' seed innovations (including not just new kinds of seeds, but also methods of seed storage, soil management etc.) based on such traditional knowledge are adequately or appropriately protected by current pigeon holes of 'narrow' intellectual property protection regimes (see also the background post **here** for details). In order to (i) promote the use of traditional knowledge based sustainable farming systems, including the use of indigenous seeds and associated soil management technologies prescribed therein, *and* (ii) to promote research and innovation on and with them, measures other than "IP-Narrow" are necessary. For this, keep track of **Prongs 2 and 3** of the SSI 2.0 recommendations (Education, DLT/Blockchain technologies), coming soon to this space.

(i) TEK in International Law and Business

International conventions, such as the Convention on Biological Diversity (CBD), have for long underscored the need to protect biodiversity within the soil (i.e. the soil microbiome) & on the soil (i.e. seed/plant biodiversity). Equally relevant is the recognition and high status given within these conventions to (a) the valuable role played by traditional knowledge & associated systems, practices, & innovations, in maintaining this biodiversity, & using it in a sustainable manner,[1] and (ii) generating social and economic benefits ("benefit sharing") for the people preserving and using this knowledge. The CBD, therefore, encourages international "cooperation for the development & use of technologies, including indigenous and traditional technologies, in pursuance of the objectives of the Convention".[2]

Particularly relevant from a business perspective is the exponentially growing popularity of Ayurveda and of products and services derived therefrom, including among European populations.[3] This growing popularity within Europe (and beyond) of products and services based in *Ayurveda*, and the

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[1] CBD (1993a)
[2] CBD (1993b)
[3] Reuters, (2017); CBI. Ministry for Foreign Affairs, (2018)

expanding consumer trust in this system of knowledge,[4] makes a strong economic and business case for the adoption of scientifically validated business models rooted in this traditional, time tested knowledge system, and for the reintroduction of farming systems that are based on this knowledge, into the mainstream. The original philosophy as well as the emerging scientific evidence recommending more widespread use of such farming systems are therefore worth looking into.

(ii) The Philosophy of Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) and associated farming systems can be considered a holistic approach to farming that promotes and enhances the health and diversity of agro-ecosystems, and facilitates complex and beneficial interactions between biodiversity, biological cycles and soil biological activities.[5] TEK based farming systems visualize human beings (and animals, such as cattle) as being a part of nature and consequently aims for co-existence and co-evolution of entities that benefit from each other through ecosystem services (synergies within the ecosystem).[6] TEK evolves experimentally and has an evolutionary character that verifies the knowledge season after season and is handed down from one generation to the next.[7] In other words, these systems evolve in harmony with local socio-cultural realities and in accordance with local site conditions. Consequently, they are deeply embedded in local (often unique) cultural, natural, social and economic practices and circumstances.[8] This essentially means that TEK based farming systems evolve independently in various parts of the world, and while they follow basic principles of nature, they do not follow any uniform 'recipe' that is flatly applicable in all regions of the world. Just like personalized medicine, therefore, traditional agricultural practices are highly localized and region specific.

Nonetheless, as noted, TEK systems do follow certain basic principles of nature, and work in close collaboration with nature. For example, farmers use the local resources to farm without any external inputs.[9] The principle of minimized loss of energy, water and nutrients contributes to a more efficient use of available resources.[10] Principles, such as the carrying capacity of the ecosystem and enhanced biomass recycling promote long-term sustainability.[11] Resources within the ecosystem are used, for example, to build an irrigation system through deep rooting trees or the harvest of rainwater.[12] In other words, in TEK based farming systems, the aim is not to "tame" nature, but to observe and work with natural cycles.[13] Nature is considered as a teacher. Every farmer, therefore, naturally turns into a researcher and innovator because only through careful observation and consideration of the local ecology, such as climate and soil conditions, can the success of planting activities be ensured.

Accordingly, seeds used in TEK based farming systems are also locally selected, multiplied, saved, improved and exchanged. Indeed, seed keeping lies at the heart of traditional agriculture, and has evolved over centuries, with farmers saving seed with desirable traits such as hardiness, yield and adaption to local soils and climates.[14] Seed keeping, when combined with spontaneous natural mutations, resulted in an astounding diversity of seeds and planting materials which are locally adapted, genetically non-uniform, variable and heterogenous.[15] In India seed keeping activities prove a rying to capture The high adaptability and hardiness exhibited by these diverse varieties allows for low cost and low input farming.[16] Further, TEK systems also provide teachings on methods of

[4] CBI. Ministry for Foreign Affairs, (2018)
[5] Altieri, (2002); Altieri and Nicholls, (1999).
[6] Korn (2015), p. 201
[7] Berkes and Turner, (2006).
[8] Briggs and Moyo, (2012), 66; Girard and Frison, (2018).
[9] Chadha, Saini, and Paul, (2012).
[10] Bonaudo et al., (2014), 49.
[11] Verhoog et al., (2003), 36; Bruins, Evenari, and Nessler, (1986); Khadse et al., (2018).
[12] Fukuoka in Korn (2015), p. 159
[13] Mother Earth News Interview with Masanobu Fukuoka (1982)
[14] Ohlson, (2014).; Thrall et al., (2011).
[15] Cebolla-Cornejo, Soler, and Nuez, (2012).
[16] Murphy et al., (2007).

increasing seed germination rates through various seed preparations (in India called Angara preparation or *Beejamrut*).[17]

(iii) Traditional Knowledge Meets Modern Science

After decades of focusing on chemical intensive, uniform/standardized farming, the modern understanding of efficient and sustainable farming is presently shifting away from artificial fertilizer and pesticide driven monoculture towards more traditional methods and practices of cultivation. Commonly known among these, are practices of mulching, low tillage, small-scale rainwater harvesting, crop rotation, inter-cropping, multiple cropping and working with the soil microbiome. Many of these practices have been documented in the ancient texts of India, Vedic- (Rigveda, Atharvaveda) and Ayurvedic texts (Charaka Samhita, Sushruta Samhita), dating back to 3000 BC – 1000 BC.[18]

More recent studies and developments help to scientifically understand, appreciate and improve upon these ancient practices for modern application.[19] This has led to a growing movement of returning to traditional and natural farming methods in India.[20]

Traditional farming uses several natural bio-stimulants and bio-pest-repellent formulations, which are simple to produce on site (at the farm), using local materials and resources, such as cow dung and urine and diverse local plants. Some preparations that are commonly used in Zero Budget / Natural Farming, for example, include:

	Name of agent	Principal contents	Use case
1	Beej-amrut[21]	Water, cow dung & cow urine from local breeds	Seed germination enhancer
2	Jeev-Amrut[22]	Water, cow dung & cow urine, raw sugar, legume flour, soil	Plant Bio-stimulant
3	Ghanjeev-Amrut	Water, cow dung & cow urine, raw sugar, legume flour, soil	Plant Bio-stimulant concentrate with longer shelf life
4	Neem-astra	Water, neem leaves, cow dung, cow urine	Pest repellant / Plant immune-strenghtener
5	Brahm-astra	Neem leaves, custard apple leaves, Guava leaves, caster leaves, papaya leaves, pomegranate leaves, cow urine, weeds that are pest resistant	Pest repellant / Plant immune-strenghtener
6	Agni-astra	Tobacco leaves, green chilli, garlic, neem leaves, cow urine	Pest repellant / Plant immune-strenghtener
7	Garbage enzyme	Kitchen / yard waste, raw sugar, water	Plant Bio-stimulant / Bio pest repellant

Additional to these products, several processes are used, such as hot composting, mulching, crop rotation, inter-cropping, multiple cropping and low tillage, all of which are already well known and documented. In Europe, for example, these practices are mostly applied in organic farming.[23]

17 Chadha, Saini, and Paul, (2012), 485.
18 Srikanth, Tewari, and Mangal, (2016).
19 Brown, (2013); Münster, (2017); Khadse et al., (2018).
20 Khadse (2018); Brown, (2013).
21 Devakumar et al., (2014).
22 Manjunatha et al., (2009); Devakumar et al., (2014).
23 Kilcher, (2007); Xie et al., (2017); Canali et al., ibid.; Ciaccia et al., ibid.; Klaiss, Siegrist, and Weidmann, (2017).

Any substance or microorganism that are applied to plants to enhance the efficiency of nutrients are called biostimulants. Such plant biostimulants include preparations composed of organic matter, minerals (such as rock-flour), and microorganisms.[24] Biostimulants foster the fertility of the soil-microbiome and consequently, the plant growth and development is improved (facilitated plant metabolism, nutrient assimilation, translocation; water is rendered more efficiently).[25] Since biostimulants foster the tolerance against abiotic stress and increase the natural resistance to pests, they contribute to better yields and crop quality.[26] Preparations that act like microbial plant biostimulants gain popularity among Indian farmers (such as those practicing zero budget or natural farming). These preparations include Beejamrut, Jeev-Amrut and Ghanjeev-Amrut, which are very close to the ancient formulation of Panchagavya (Sanskrit: five products of the cow) which is composed of cow dung, cow urine, milk, curd and clarified butter. Ananda C. (2011) and Chadha et al. (2012) demonstrated the positive effects of these traditional microbial fertilizers.[27] Ananda C. (2011) reported similar increase of plant yield when comparing Panchagavya to NPK chemical fertilizer. However, while the chemical NPK fertilizer reduced microbial populations in the soil, Panchagavya increased them, pointing out a possible difference in sustainability for these two approaches.[28] Manjunatha et al. (2009) found significant increases in yield of sunflower seeds using the Jeev-Amrut preparation.[29] Chadha et al. (2012) also reported significant increase in yields when using these traditional preparations, and also reported their effectivity in controlling several plant pathogens.[30]

Chemical analysis of these preparations done by Chadha et al. (2012) also showed presence of bio-available Nitrogen, Phosphorus and Potassium, as well as the presence of several trace elements (S, Ca, Mg, Fe, Mn, Zn, Cu).[31] Timmusk et al. (2017) summarizes the effectivity of employing Plant Growth Promoting Bacteria (PGPB) and Rhizobacteria (PGPR) and concludes that the potential of such formulations can be brought to wider field application by further systematic studies and standardization.[32] Mauchline et al. (2017) come to a similar conclusion in their study of the soil microbiome and particularly the interplay of *Pseudomonas* and the wheat rhizosphere, stating that: “a better understanding of the soil microbiota, combined with smart manipulation of plant cropping systems may present a reliable future route to sustainable yield improvement and biocontrol.”[33] There is ample, current research on plant microbe interaction and the soil microbiome regarding agricultural application, all lauding the promise of microbe powered sustainable agriculture.[34]

Any natural farming method or agricultural model that aims to be economically sound and sustainable, to preserve and enhance biodiversity and thus increase the resilience of an ecosystem while using minimal or zero external input of nutrients or synthetic pesticides, requires local varieties of crops to succeed.[35] Such varieties are already adapted to their environment over an extended time span and often display high resilience to biotic and abiotic stress present in that environment.[36] Hence, the vitality of seeds of local crop varieties is essential. Bheej-Amrut is a seed-stimulant preparation among the TEK bio-stimulants from India, which seems to be an excellent aid in such seed-keeping efforts. Bheej-Amrut is typically composed of water, cow dung, cow urine, limestone and local soil

[24] Bundesamt für Verbraucherschutz und Lebensmittelsicherheit,, (2009)
[25] European Biostimulant Industry Council,
[26] du Jardin, (2015).
[27] Ananda, (2011); Chadha, Saini, and Paul, (2012).
[28] Ananda, (2011).
[29] Manjunatha et al., (2009).
[30] Chadha, Saini, and Paul, (2012).
[31] Ibid.
[32] Timmusk et al., (2017).
[33] Mauchline and Malone, (2017).
[34] Finkel et al., (2017); Jansson and Hofmockel, (2018); Santoyo et al., (2016).
[35] Wezel et al., (2018); Rankoana.
[36] Girard and Frison, (2018); Turvey, Bryant, and McClune, (2018).

and hence easy to produce on site.[37] Devakumar (2014) found Bheej-Amrut to contain N-fixing, P-solubilizing bacteria, actinomycetes and fungi. Souman et al. (2009) also reports the presence of indole acetic acid (IAA) and gibberellic acid (GA) producing bacteria in Bheej-Amrut.[38] Furthermore, Bheej-Amrut-treated seeds show an increased germination rate and seedling length.[39] These findings suggest that Bheej-Amrut may be a suitable preparation to aid in local, farm-scale seed keeping and the revival of local crop varieties.

Another microbial preparation, commonly called “garbage enzyme”, is produced by fermenting household or industrial fruit and vegetable peels and scraps. Its production is simple and low cost. The garbage enzyme preparation is associated with increased solubilization of Phosphorus from solid deposits.[40] The efficacy of soluble and mineral Phosphorus enrichment of soils by microbes has been described by Sharma et al. (2013), which points out how garbage enzyme could benefit plant vitality and yields in agriculture.[41] Other documented use of garbage enzyme includes the treatment of synthetic greywater,[42] and waste activated sludge.[43] In both use cases, the results point toward increased solubilization of solids from the substrate, which in turn may facilitate bacterial treatment and use of these waste materials as bio-resources.

Other well-documented processes employed in traditional agriculture, and increasingly validated by modern science, include mulching and low tillage, which have been demonstrated to improve several soil properties considered crucial for productive agricultural use.[44] Xiao-Yan Li et al. (2001) found increases of corn grain yield of 20 - 95 % by mulching, depending on the availability of water: the dryer the year, the greater the improvement of grain yield.[45] Low tillage is a practice that is gaining more and more attention in the sustainable farming context and its efficacy has been shown in several studies.[46] Hot composting (Berkeley composting) is also used in SSNF as a simple and low-cost method to fully utilize all excess biomass available and rapidly convert it into a versatile bio stimulant for use in agriculture.[47]

The state of current research as outlined above, strongly underlines the promise of traditional sustainable farming methods, and makes a clear case for the revival of TEK based farming systems, and employing, where relevant both ancient and modern techniques and processes together.

The question that arises, of course, is how one can concretely go about reviving and introducing TEK based farming systems into mainstream agriculture. Here, the SSI 1.0 working groups emphasized the relevance of (re)education through diverse channels – both formal and informal. Informal efforts through NGOs and spiritual leaders of India is ongoing. More formal efforts at regulation and policy level are, however, also necessary.

In this context, it is noteworthy that despite the importance of TEK based farming systems and its ability to spur farmer level innovations (as seen also in **Jitul Saikia’s story**) and enhance environmental health, current intellectual property rights regimes are neither equipped nor appropriate to protect innovations (including seed innovations) emerging from the practice of TEK based farming systems. Although the Indian PPV&FR Act recognized farmers’ rights, and permits the registration of extant varieties (including farmers’ varieties), such varieties still have to comply with the definition of

[37] Devakumar et al., (2014).
[38] Souman et al., (2009).
[39] Nemagoudar et al., (2014); Sornalatha, Tamilarasi, and Esakkiammal, (2018).
[40] Nazim and Meera, (2013); Arun and Sivashanmugam, (2015).
[41] Sharma et al., (2013).
[42] Nazim and Meera, (2013).
[43] Arun and Sivashanmugam, (2015); (2017).
[44] Mulumba and Lal, (2008).
[45] Li et al., (2001).
[46] Mulumba and Lal, (2008); Sharma et al., (2015).
[47] Blanc et al., (1997).

variety under the PPV&FR Act and are permitted only a few more 'off types' than breeders' varieties. Undoubtedly, the Indian law also recognizes and rewards seed conservers under their Plant Genome Savior awards (awarded to individual farmers as well as farmer communities). Yet, the number of awards as well as the fact that these are one-time awards make limit their effectiveness as tools to promote and incentivize sustainable seed innovations. Revisions in educational curriculums, agricultural extension services curriculums as well as technical solutions can aid legal and policy measures aimed at promoting the adoption of TEK based farming systems such as ZBNF. We discuss these measures in Prong 2 and Prong 3 of our SSI 2.0 project and position paper.

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