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MANAGING NATURAL RESOURCES AND SAFEGUARDING HUMAN HEALTH: IS EXTENSION DOING JUSTICE TO THIS CHALLENGE?

In this blog, SVN Rao argues for having an extension strategy for Natural Resource Management so as to address the deteriorating natural resources critical for sustainable agricultural development.

CONTEXT

Natural resources such as soil, water and air are crucial for agriculture. These three key resources are interconnected to each other in one way or another. Meddling with one will always have an adverse effect on the other two. Human actions play a pivotal role in conserving these resources for sustainable agriculture. But, in the race to develop agriculture (to improve the country's economy) through the introduction of modern technologies, are we forgoing to manage the quality of these resources? There is evidence on the deterioration of natural resources and risks to human health due to some of the modern agricultural developments. Given that extension professionals at the grassroots level transfer technologies from lab to land, are they really weighing the consequences of their actions on natural resources? In this blog we look into certain critical issues that affect Natural Resource Management (NRM). For example, what are the government initiatives that really touch conservation practices and what are the competent strategies that extension professionals/policy makers can bring to the table while promoting NRM?

AGRICULTURAL DEVELOPMENT AND DETERIORATING NATURAL RESOURCES

In the case of India, agriculture and allied sectors have contributed a fair share to the progress of its economy. Research and extension interventions in this area have helped the country to become self-sufficient in food production. But, how have these efforts impacted the quality of natural resources and the environment? If we consider just one example, that of promoting input intensive agriculture, this has led to higher use of chemicals on soil and environment resulting in reduced soil fertility, soil nutrient imbalance, over exploitation of groundwater, deforestation, crop burning and others. These actions led to depletion of the groundwater table, water logging, air pollution etc. In addition, some actions, such as crop burning, water pollution, were also found to have severe effects on human health (Chakrabarti et al. 2019; Kumar et al. 2019; GoI 2018; Suresh et al. 2018; Dar et al. 2017; Dhawan 2017; Singh et al. 2017; FAO 2015).

The consequences of chemical usage in agriculture/nature was highlighted in Rachel Carson's 1962 classic Silent spring, where she mentions, "In nature, nothing exists alone. If you harm environment, you will be harmed". This applies even today. Human attitude and acts towards nature is also critically valid. There is a need for transformation in agricultural practices regarding management and conservation of natural resources, where extension functionaries have a key role to play. Contemporary extension services are actively focussed on transfer of input intensive technologies among farmers. But, are there any efforts which help farmers to understand the implications of these technologies on the environment? So there is a need to understand such aspects.

Pollution of Natural Resources (Land, Air, Water) and Policy

Agricultural and industrial practices can lead to natural resource pollution. Industrialization, mining activities, urbanization, and deforestation are some of the important causes for natural resource pollution. Soil degradation in India was estimated to be occurring on 147 million hectares (Mha) of land, including 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, nine Mha from wind erosion, six Mha from salinity, and seven Mha from a combination of factors. Inappropriate agricultural practices such as excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning are leading causes of soil deterioration. Additionally, social causes like land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty, and population upsurge are also contributing to soil degradation (Bhattacharyya et al. 2015). There is need to manage and conserve the health of soil, which is a vital living ecosystem for sustenance of plants, animals and humans (NRCS-USDA 2021).

The UN Food and Agriculture Organisation (FAO) declared 2015 as the International Year of Soils (Box 1). In 2002, recognising the need to raise awareness on soil conservation and soil health ecosystem, the International Union of Soil Sciences with the support of FAO recommended that World Soil Day be celebrated annually. Last year we celebrated World Soil Day (2020) with the theme Keep soil alive, protect soil biodiversity, emphasising the effects of increasing population on soil, and urging all to consider the contributions of soil organisms to soil processes without which life on earth would be impossible.

BOX 1: International Year of Soils

FAO declared 2015 as the International Year of Soils with a slogan 'Healthy soils are the basis for healthy food production'. It is estimated that 95% of the food is produced directly or indirectly on soils. Healthy soils are the foundation of the entire food system. Soil is the basis for agriculture and the medium in which nearly all food-producing plants grow. Healthy soils produce healthy crops that in turn nourish people and animals. Soil quality is directly linked to the quantity and quality of food produced. Soils supply all essential nutrients, water, oxygen and root support that our food-producing plants need to grow and flourish. They also serve as a buffer to protect delicate plant roots from drastic fluctuations in temperature.
(http://www.fao.org/soils-2015/news/news-detail/en/c/277682/)

Initiatives from the Government of India – Paramparagat Krishi Vikas Yojana (PKVY) under National mission on sustainable agriculture towards soil health management, Soil Health Cards (SHC) schemes – have been in place from 2015 to conserve soil health (GOI 2017). Awareness about these programmes are created through broadcast news, campaigns at field level by extension professionals, and trainings provided for farmers so as to recognise the importance of conserving soil health. Farmers are facilitated with soil testing and residue analysis facilities at minimal price from state/nationally established laboratories. But some of the capacity gaps within the extension system led to faulty implementation of this scheme in several places. For instance, ineffective sample collection from farmers' fields, farmers' inability to understand the results of SHC reports/technical trainings given to them, and poor availability of timely input/lab facilities were found to be major gaps in implementing this scheme (Reddy 2017; Kishore et al. 2021).

Air quality deterioration is another major concern resulting from the actions of humans mainly in industrial and agricultural sectors. The resulting air pollution from agriculture in the form of ammonia and other forms of toxic emissions, combines with pollutants from combustion — mainly nitrogen oxides and sulphates from vehicles, power plants and industrial processes — to create tiny solid particles, or aerosols, no more than 2.5 mm across and about 1/30th the width of a human hair. These

aerosols have a severe effect on human health causing heart or pulmonary disease and in extreme cases leading to death (Journal of Nature, 2015, Geophysical Research Letters).

The crop-waste burning in north western India is one of the classic examples of air pollution from agriculture. It has adverse effects on the environment, mainly with regard to emission of greenhouse gases, increase in particulate matters and smog, deterioration of soil fertility. The emission of particulate matters from crop residues are found to be 17 times more than that from other sources (vehicle emission, garbage burning and industrial discharge) in Delhi (Jitendra et al. 2017). This pollution not only contributes to global warming, loss of fertility of agricultural biodiversity, but also has hazardous effects on the health of millions living in the North, mainly Delhiites and their neighbours. The practice is commonly observed during November and December months in north western India (Thakur 2017; Jitendra et al. 2017; NPMCR 2014; Punera et al. 2018) (Box 2).

BOX 2: Crop Residue Burning in Northwestern India

Northwestern India is known as the 'breadbasket' of the country producing two-thirds of food grains, with wheat and rice as the principal crops grown under the crop rotation system. Agricultural data from India indicates a 25% increase in the post-monsoon rice crop production in Punjab during 2002–2016. NASA's A-train satellite sensors detect a consistent increase in the vegetation index (net 21%) and post-harvest agricultural fire activity (net 60%) leading to nearly 43% increase in aerosol loading over the populous Indo-Gangetic Plain (IGP) in northern India. The ground-level particulate matter (PM 2.5) downwind over New Delhi shows a concurrent uptrend of net 60%. The effectiveness of a robust satellite-based relationship between vegetation index — a proxy for crop amounts, and post-harvest fires — a precursor of extreme air pollution events, has been further demonstrated in predicting the seasonal agricultural burning. An efficient crop residue management system is critically needed for eliminating open field burning to mitigate episodic hazardous air quality over northern India (Jethva et al. 2019).

There are several policy initiatives under Government of India with regard to pollution control and crop waste management, namely, The Air (Prevention and Control of Pollution) Act, 1981; The Environment Protection Act, 1986; The National Tribunal Act, 1995; The National Environment Appellate Authority Act, 1997; National Policy for Management of Crop Residue (NPMCR), 2014; and Section 144 of the Civil Procedure Code (CPC) to ban burning of paddy. The National Green Tribunal has imposed strict measures in the states of Rajasthan, Uttar Pradesh, Punjab and Haryana to limit crop residue burning and the act of crop residue burning is a punishable offence. Despite all these initiatives and measures, the problem demands more emphasis on sustainable crop management practices, such as live composting, biochar production, in situ management with mechanical intensification (Bhuvaneshwari et al. 2019).

Studies point to the fact that farmers mainly burn crops due to narrow turnaround time between summer and winter crops, labour-cost concerns, as well as limited incentives and cost-effective equipment that can mechanically cut down the stubble. In addition, unspecific follow-up of these initiatives, limited awareness among farmers, poor monitoring and evaluation measures all hold back the problem for long (Bhuvaneshwari et al. 2019; Lohan et al. 2018; Jitendra et al. 2017). These gaps indicate the need to strengthen the research-extension system technically in order to address the issue.

In the case of Punjab-Haryana, the management of rice residue left after mechanized harvesting in the rice-wheat cropping system is challenging due to heavy straw load, short time window between harvesting of rice and wheat, which together are considered to be the major reason for farmers resorting to straw burning. One promising solution is the 'happy seeder', which combines straw incorporation and sowing of wheat seeds with minimal soil disturbance. Scientific trials and

demonstrations have recorded the positive benefits of the happy seeder both in terms of reduced straw burning and increased yield. Increasing the availability of happy seeders and extension efforts to out scale the technology can go a long way towards minimising air pollution due to straw burning (Kumar et al. 2019; Sidhu et al. 2015). Similarly zero till method, which involves minimum soil disturbance and direct sowing of wheat seeds into the rice stubbles is a proven climate smart technology in these regions of northern India (Khan et al. 2016). Such technological promotions have wider scope in resource conservation – and this is where extension can play a key role.

Recently, the Indian Agricultural Research Institute (IARI), New Delhi, developed a technology in solution form called 'PUSA Bio-Decomposer', which has potential to prevent stubble burning. Upon application, the solution decomposes the crop residue into manures in 15-20 days and avoids stubble burning. This helps the farmers to take up the next crop easily. This was tested successfully through on farm trials in farmers' fields. The Delhi government has taken active steps to multiply and distribute it among the farming community in respective regions, and the extension institutes/professionals have vast scope to reach such initiatives effectively to farmers (The Hindu 2020).

Groundwater is another important natural resource under discussion where over exploitation of groundwater in states like Punjab, Haryana, and others (GOI 2018; Dhawan 2017) and excessive pumping of untreated urban and industrial wastes directly into rivers and water bodies, and over use of chemicals, pesticides, fertilizers, etc., result in the depletion and pollution of groundwater. The excessive use of inorganic fertilizers and manures in agriculture have increased the nitrate levels in water resources, which results in adverse health outcomes in humans (besides methemoglobinemia), for example colorectal cancer, thyroid disease, and neural tube defects, when consumed (Ward et al. 2018). Excessive irrigation with polluted water leads to salination which in turn results in lower crop yields and renders fresh water undrinkable (Raychaudhuri et al. 2014). Further, the runoff from agricultural lands overstimulates the growth of algae which gets decomposed, robbing water of vital oxygen and harming aquatic life.

Large scale fish farming in areas like Kolleru (Andhra Pradesh) is contributing to environmental degradation. Aquaculture which uses lots of chemicals and pesticides discharge waste and chemicals into the environment thus posing serious threats to ecological balance. Over the years due to vast expansion of aquaculture farms in this region, once the largest fresh water lake in India is no longer a lake and the area was reduced to about 35% of its original size and this area is also in a degraded state (Box 3).

BOX 3: Assessment of impact of aquaculture on Kolleru Lake (India) using remote sensing and Geographical Information System

It was estimated from the topographic maps of 1967 that the total lake boundary area was 180.38 km2, in which 70.70 km2 had water throughout the year and 100.97 km2 had water during the rainy season. The digital image processing of the 2004 satellite data revealed that Kolleru was no longer a lake and the lake area of 62.65 km2 (34.73%) only remained in a degraded state, extensively colonized by macrophytes. The total loss of lake area was 109.02 km2 between 1967 and 2004, in which aquaculture was developed in 99.74 km2, which represented 55.3% of the 1967 lake area. The maximum conversion to aquaculture occurred in the lake liable to be inundated during the 1967 rainy season. The area under agriculture was 16.62 km2 in 2004, the increase in lake area for agriculture between 1967 and 2004 being 8.22 km2 (4.55% of lake). If human induced degradation is allowed to continue, the lake will very soon disappear. Now, the Government of Andhra Pradesh, India, has initiated schemes and laws to restore the lake to its pre-development state. Lessons learnt from the Kolleru Lake cautioned that there is need for regular monitoring of important water resources throughout the world to sustain the natural resources for future (Jayanthi et al. 2006).

The link between drinking polluted water and using polluted water in agriculture can result in health hazards which was observed in the case of Eluru city of Andhra Pradesh, India. People suddenly fell unconscious after suffering from fits and nausea. The medical diagnosis reported that the presence of lead and nickel content in drinking water and milk was the root cause of this disease (News 18, Dec 08, 2020). The rivers are polluted by industrial and urban wastes. When the improperly treated industrial/ sewage water is used in urban and peri urban areas for cultivation of green fodder and vegetables, it leads to serious health hazards for humans due to indirect consumption of heavy metals through milk and food. Similarly, indiscriminate use of pesticides and fertilizers, especially in Malwa region of Punjab, led to increase in cancer cases. Due to increase in cases and more movement of cancer patients from Malwa, Punjab to Bikaner, Rajasthan, to avail subsidized treatment for cancer, the connecting train (Bhatinda-Bikaner) is popularly known as 'cancer train'. These cases highlight the magnitude of health risks associated with indiscriminate use of agro-chemicals.

For better governance of water, and to reduce pollution and depletion the Government of India has promulgated several policy initiatives , such as National Water Policy (1987, 2002, 2012), National Water Mission (2009) under National Action Plan on Climate Change (NAPCC) with focus on natural resource conservation. These have espoused strategies like recharging of aquifers, conjunctive use of surface and groundwater, controlled extractions, improved agronomic practices and others that have the potential to conserve the natural resources at farm level through improved soil treatment, increased water use efficiency, judicious use of chemicals, labour and energy, and increased soil carbon storage, etc. (GOI 2012; GOI 2010).

Similarly the government has taken up initiatives to promote Zero Budget Natural Farming which was highlighted in the 2019 Union Budget, to conserve natural resources and the environment from pollution and also to promote sustainable agriculture. This programme focusses mainly on chemical-free agriculture, which mainly relies on agro-ecological approaches. It is primarily dependent on organic inputs and claims that there is no application of external inputs for cultivation. So, when there is no external application of fertilizers/pesticides, the soil quality will be conserved and in turn the water and air quality is also maintained. The environment will not have any pollution from the chemicals used in agricultural practices. However, the upscaling of these initiatives requires proper incentive structures, aligning them with farmers' values and extension efforts. There are many examples from the natural resource conservation field, which looks good on paper, performs well in scientific trials, but raise no interest in farmers.

The study conducted by Reddy et al. (2004) based on secondary data to assess the impact of incentives on the adoption and maintenance of Soil and Water Conservation (SWC) practices/assets in India concluded that though the government is tackling land degradation in an integrated manner investing huge money on ameliorative measures, the farmers' response to the state initiatives has been a mixed one. Farmers adopt and sustain only those SWC measures, which ensure adequate internal economic incentives, involve less cost and call for low collective action. Though most of the SWC practices are worthwhile from an evaluation point, it is essential to focus on adequate internal incentives and multiple objectives of farmers in matters of conservation for long-term sustenance of SWC. They recommended that a combination of subsidy and credit be explored for certain types of SWC that can enhance incentive regimes. Special emphasis need to be placed on the livestock component in SWC for fodder development and grazing facilities, which not only fetch higher returns to farmers but also prevent soil erosion due to the soil-binding property of grasses and plants. Extension agents need to play an important role in devising strategies to promote adoption of the complementary technologies, which not only benefit farmers but also conserve the environment.

GAPS IN NRM EXTENSION

Historically, extension at the grassroot level placed higher emphasis on production-centric technologies, in line with national priorities. However, with India becoming self-sufficient in food production and a net exporter, we need to focus on conservation of natural resources. The government has also started many initiatives to promote sustainable agriculture, which balances the environment and economy trade off. The extension system needs to evolve and focus on incorporating technologies which promote resource conservation. However, it is easier said than done. Generally, the benefits of natural resource conservation are realised in the long term, the immediate impact may not be observable. The consequences of resource depletion is also gradual, so making farmers understand the need, importance and benefits of resource conservation can be challenging.

For example, Kishore et al. (2021) argues that the Soil Health Card scheme and the subsequent fertiliser dose recommendation had negligible effect on both farmers' understanding as well as their actual fertiliser use. The authors opine that educating farmers, simplifying the interpretation, personal visits or tele advice, and repeated engagement with farmers is needed to make farmers understand the importance of soil tests and adjust fertiliser use accordingly. Similar observations are also made by other researchers like Reddy 2017; Singh and Ganguly 2018; Kumar et al. 2020)

There might be several such cases where the need for extension action was undermined by the policy which did not allocate enough budget for capacity building of extension professionals and in developing several teaching aids to educate farmers on various aspects related to NRM. We need to learn from other countries that are successfully helping their farmers in employing appropriate strategies designed to manage natural resources. Some of these strategies are mentioned below.

Soil health strategies promoted in USA

Many organizations/universities in the USA have come out with several educational tools to help farmers on different aspects of soil health. These tools include manuals, videos and webinars, blogs,

slides, etc. Further, the universities also have specialized programmes to train manpower in the area of resource extension. For instance, there are NRM programmes under Cooperative Extension at Cornell University, which offers a certificate programme on pesticide management, and safety education.

The University of Maine, USA, developed strategies for farmers to maintain soil health; and their primary strategies to improve and maintain soil health include reducing soil disturbance, keeping the soil covered as much as possible, growing a variety of plant types, and adding organic materials, such as crop residues, manures, and compost.

One example of the way the cover cropping strategy is being adopted by the farmers is given in Box 4. To quantify the benefits of cover crop in monetary terms, the farmers are advised to use resources such as the Cover Crop Economics Calculator by the USDA – Natural Resources Conservation Service. This helps farmers to realise the economic benefits of adoption. Likewise, the University is assisting the farmers in using other strategies.

BOX 4. Promoting cover crops

Cover cropping is an increasingly popular and important practice for improving economic and environmental sustainability on many Maine farms. Cover crops are plants used to improve soil health and fertility, provide beneficial insect habitats, reduce weed pressure, and/or provide other agronomic or environmental benefits. Cover crops are generally not harvested for profit, but used to improve water quality, reduce fertilizer needs, decrease insect, pest and weed pressure, protect against soil erosion, and increase cash crop yields. For example, the specific considerations for cover cropping are:

1. Setting goals – improve soil organic matter, increase soil microbial activity, improve soil structure, decrease erosion, decrease weed populations;
2. Timing – determine what time of year you can plant the cover crop and how long you can leave it in the field;
3. Planting cover crops – fertility, soil preparation and weed management;
4. Seeding rates;
5. Planting equipment;
6. Termination and incorporation.

https://extension.umaine.edu/agriculture/soil-health/

The above examples indicate the importance given to natural resources and how academicians and extension professionals are educating farmers through the development and use of several extension teaching tools that enable farmers to understand and use appropriate strategies for sustainable crop and livestock production.

WHAT COULD BE DONE TO STRENGTHEN NRM EXTENSION

To contribute effectively to NRM, extension services should have sufficient support and strategies for behavioural change communication where extension activities must motivate farmers to participate, learn, trial, and adopt resource conservation and management practices (Mendham et al. 2007). There might be several resource conservation interventions but the basic principles will be essentially the same (Pannell et al. 2006). It is also necessary to involve the private sector in promoting the adoption of soil and water conservation technologies as suggested by Alwin and others (2019) based on a study conducted on zero tillage wheat adoption in Bihar.

It also depends on the extension professionals as to how well he/she can make the farmers understand the importance of the health of natural resources, and how to manage them for optimal and sustainable crop and livestock production.

For example, extension professionals must adopt strategies such as:

- Playing games to conserve water (Meinzen-Dick et al. 2018); How collective action can be promoted in conservation of a common property resource;
- Agro-climatic zone-based crop plans need to be promoted which balances environment and economy;
- Promoting farmers' community actions and community monitoring of resources (watershed projects; organic farmers associations);
- Short courses, seminars, study tours on NRM for extension professionals, students and farmers;
- Transfer updated information to farmers. This includes updating the content of package of practices, and recommending suitable eco-friendly practices which help farmers to manage and conserve resources;
- Designing and developing appropriate updated knowledge resources like context specific manuals, books, handouts, leaflets, etc.;
- Capacity building of extension professionals and also the concerned technical staff;
- Mandatorily conduct soil and water testing by the farmers in approved STLabs;
- Provide information to farmers on pollution control Acts and Laws and also keep them informed about the fines and other punishments for contaminating/polluting natural resources;
- Repeated advocacy and authentic education provided to farmers, specifically on effects and future consequences of natural resource pollution through use of pesticides/chemicals; crop burning actions.

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