Why nudging farmers for volunteer adoption of soil and water conservation technologies in rainfed areas of India is challenging?

Suresh Kumar, D. R. Singh, M. Madhu and Rajesh Bishnoi

Rainfed agriculture in India is facing multiple biophysical (erratic and uncertain rainfall, depleting groundwater resources, unpredictable droughts, soil degradation and increasing climate variability) and socio-economic constraints (low level of adoption of improved crop production practices, population pressure, widespread poverty and inadequate infrastructure), resulting in low productivity and low farm income. This in turn leads to low investment capacity of resource-poor farmers in the region. All these factors eventually result in land degradation–poverty nexus in the region. To break this nexus, among the technological and institutional approaches, adoption of soil and water conservation (SWC) technologies is of prime importance because of their multiple and synergetic effects in improving soil health and enhancing crop productivity, thereby helping to secure the livelihood of resource-poor farmers of the region. Recognizing the importance of SWC in sustaining crop production in rainfed areas, SWC technologies are being made popular through watershed programmes, which have been implemented since 1980s. In the watershed programmes, a major part of the cost is borne by the State and/or Central Government. However, in spite of the well concerted efforts by different institutions, voluntary adoption of physical SWC technologies is still low. However, due to lack of data, actual rates of adoption of different SWC technologies cannot be presented. In this note, we unravel the probable reasons for low adoption of SWC technologies in rainfed areas. For this, all the constraints and challenges are divided into four major groups: (1) socio-economic, (2) policy issues, (3) biophysical and (4) technological constraints.

Socio-economic constraints

Poor investment capacity of farmers in rainfed area

In India, rainfed areas are witnessing multiple constraints, problems and challenges (Figure 1). Because of this, farmers in rainfed areas are in the grip of the vicious cycle of water–food–livelihoods–poverty–land degradation, wherein land degradation coupled with frequent droughts results in the low productivity–low income–low investment cycle[1]. In rainfed areas, small and resource-poor farmers, in particular, who are more than 80%, have low investment capacity and thereby low adaptive capacity, which in turn accentuates their vulnerability to various risks of rainfed agriculture[2].

Increasing opportunities of off-farm income

Increasing non-farm employment opportunities and widening disparities between wage earnings in the agricultural and non-agricultural sectors, have encouraged rural people to migrate to urban areas for seemingly better work opportunities, particularly from rainfed areas[3–5]. Increasing off-farm employment or income opportunities may imply that less preference is given to farming as a livelihood option, particularly in rainfed areas where production risk is very high due to dependence on erratic rainfall. Therefore, inclination of farmers towards the avenues of off-farm income reduces the adoption of SWC measures and other new technologies.

Policy issues

Subsidy-driven adoption of SWC technologies

Primarily, SWC measures are being taken up on a watershed basis, wherein the major expenditure (around 90–95% of the total cost of watershed management) is being borne by the government, while the farmers' contribution of 5–10% is kept in the watershed development fund (WDF) for aftercare works of common structures. With expansion of such government-funded watershed programmes, farmers have largely understood or formed a deep perception that SWC is the responsibility of the public institutions. Therefore, farmers tend to wait for their turn for watershed programmes in their areas, rather than opting self-financed SWC investment. As rightly pointed out by Smith[6], the side effects of subsidies for SWC activities are that neighbouring villages tend to postpone self-financed SWC investment until the project arrives in their villages or postpone maintenance in the hope that future projects will pay for it[6]. Moreover, such subsidized programmes also discourage farmers from thinking for

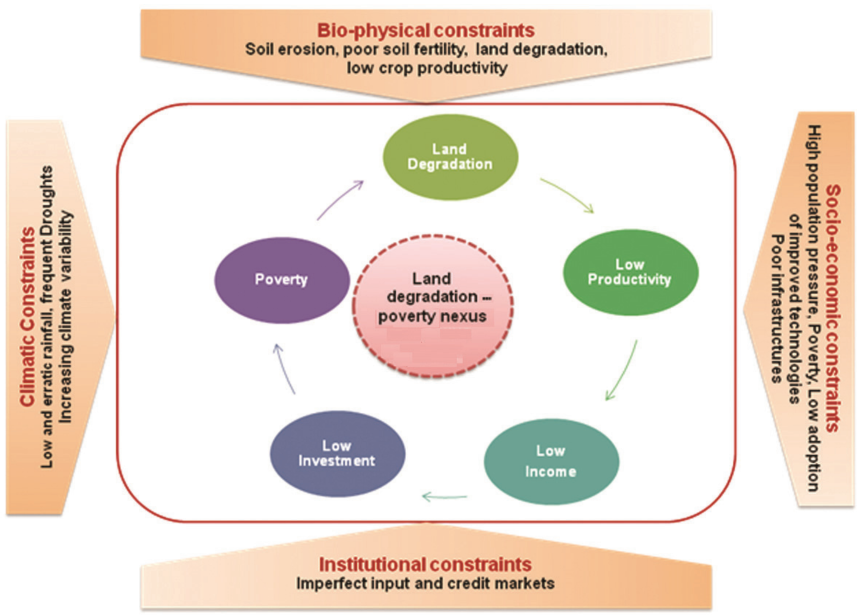

Figure 1. Land degradation–poverty nexus in rainfed areas in India.

themselves and developing other, perhaps cheaper, solutions and use their traditional knowledge and practices for conserving natural resources[7]. In a recent study conducted in drought-prone areas of Karnataka, Kumar *et al*.[8], observed that among the different constraints to the adoption of SWC measures, the non-adopters waiting for watershed programmes in their areas was reported as the major reason for postponing or not taking up physical SWC measures by farmers.

Skewed price policy and free electricity for groundwater irrigation

Due to skewed price policy, particularly for rice, wheat and sugarcane, farmers tend to prefer these water-guzzling crops requiring assured source of irrigation over traditional crops of rainfed areas such as millets, pulses and oilseeds. Therefore, farmers prefer to have a tube well as the source of irrigation (with free or highly subsided supply of electricity in most of the states), as is evident from the increasing number of tube wells in India. Such farmers with assured irrigation facilities do not invest in physical SWC technologies as benefits from them are less than those realized from irrigated crops, since water-intensive crops like paddy produce stable yields with less production risk coupled with remunerative prices. Similarly, in peri-urban areas, farmers diversify the cropping pattern with inclusion of high-value crops, particularly vegetable production, requiring irrigation facilities with little or no adoption of physical SWC technologies.

Biophysical constraints

Tenure insecurity and shrinking size of land holding

Land tenure security shapes land-use decision of farmers, particularly decisions relating to land management investments[9]. Often farmers are reluctant to invest in technologies to conserve land resources, when the future rights to use them are not secure. With increasing focus on the off-farm income and urbanization, large farmers tend to lease out their land to the smallholders. Under such circumstances, farmers who take the land on rent are also not interested in investing in activities relating to SWC measures, given the fact that because of tenure insecurity such farmers are unable to harvest long-term benefits of SWC efforts. Further, fragmentation of land holdings and their shrinking sizes which have decreased from 2.28 ha in 1970–71 to 1.08 ha in 2015–16; not only force the farmers to move away from farming and compel the smallholders to migrate and search for better opportunities in other sectors, but also make adoption of new technologies or costly SWC investment difficult[10], rendering disincentives first due to economically unviable small scale and secondly, due to technical infeasibility to take up SWC measures[10].

Increasing climate variability

In the view of increasing climate variability manifesting in terms of increased incidence of droughts, farmers are not able to realize the potential benefits of SWC measures, particularly when droughts are consecutive in nature. Under such situations, the difference between adopter and non-adopter farmer is neither noticeable nor satisfactory to encourage the latter to take-up the SWC measures. This reduces the demonstration value of such SWC programmes failing to motivate non-adopters to take up these measures. Under the situation of consecutive severe droughts, even the adopter farmers become disillusioned, and form a perception about the ineffectiveness of SWC technologies.

Institutional and technological constraints

Imperfect credit and input markets

Particularly in the rainfed areas of developing countries, it has been widely discussed and reported that rural markets and social institutions are thin and scattered and work poorly due to high transaction costs, which in turn adversely affects the adoption of SWC technologies due to poor forward and backward linkages. Consequently farmers neither have access to improved inputs and improved technologies nor are able to realize the potential benefits of their produce.

Lack of technical support from institutions

Execution of SWC measures (soil bunds, check dams, recharge filters and farm ponds) needs a scientific structural design for constructing a site-specific, cost-effective and efficient structure for realizing the potential benefits. Therefore, for their execution and implementation the technical support is indispensable given the diverse agro-ecological conditions in which the farmers operate. Poorly designed SWC structures not only result in sub-optimal benefits, but may also lead to disenchantment, i.e. discontinue the adopted SWC technologies. Kannan *et al.*[11] identified that one of the major reasons for non-adoption of SWC technologies by farmers in rainfed areas is the incompatibility of such technologies with socio-economic conditions and risk-bearing ability of the farmers. Therefore, technologies should not be recommended based on the approach of 'one size fits all', but should be fine-tuned with the socio-economic conditions of the farmers. Therefore, lack of technical support or poor access to SWC technologies is viewed as a major barrier to their adoption, even if some farmers are prepared to invest.

Little or unperceivable long-term benefits of conservation

Particularly in drought-prone rainfed areas, for a farmer the driving factor for adoption of SWC technologies is their short-term economic benefits. However, the long time-span to get returns from SWC technologies reduces the possibility of adoption, particularly in drought-prone rainfed areas where most of the farmers are resource poor having limited capacity to invest. Further, the long-term environmental effects (soil health, restoration of soil fertility, etc.) of SWC measures are not so obvious to or are poorly communicated to the farmers, with little positive effect on the prospects on adoption of such technologies.

In a nutshell, it can be stated that all the aforesaid constraints and challenges must be considered while formulating conservation plans and policies for effective and widespread adoption of SWC technologies for conserving degraded natural resources and sustaining the livelihood of resource-poor farmers of rainfed areas.

1. Wani, S. P., Rockström, J. and Oweis, T. Y. (eds), *Rainfed Agriculture: Unlocking the Potential (Vol. 7)*, CABI, Oxfordshire, UK, 2009.
2. Raghavendra, K. J. and Suresh, A., *Indian J. Agric. Sci*., 2018, **88**(6), 895–901.

3. Reddy, D. N., Reddy, A. A., Nagaraj, N. and Bantilan, M. C. S., Rural Non-Farm Employment and Rural Transformation in India, Working Paper Series No. 57, International Crops Research Institute for The Semi-Arid Tropics, Patancheru, Hyderabad, 2014.
4. Chand, R., Srivastava, S. K. and Singh, J., Changing Structure of Rural Economy of India Implications for Employment and Growth, Discussion Paper, NITI Aayog, New Delhi, 2017.
5. Agrawal, T. and Chandrasekha, S., Short Term Migrants in India: Characteristics, Wages and Work Transition, Working Paper No. 7, Indira Gandhi Institute of Development Research, Mumbai, 2015.
6. Smith, P., The use of subsidies for soil and water conservation: a case study from western India, Network Paper No. 87, Agricultural Research & Extension Network, Overseas Development Institute, London, UK, 1998.
7. Bunch, R., *Mt. Res. Dev.*, 1999, **9**(3), 213–219.
8. Kumar *et al.*, Economics and soil and water conservation in rainfed areas of Karnataka, Ph.D. thesis, Division of Agricultural Economics, Indian Agriculture Research Institute, New Delhi, 2020.
9. Paltasingh, K. R., *Land Use Policy*, 2018, **78**, 236–244.
10. Gulati, A. and Juneja, R., Transforming Indian Agriculture, Discussion Paper in National Dialogue, Indian Agriculture towards 2030: Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food Systems, 2021; http://www.fao.org/fileadmin/user_upload/FAO-countries/India/docs/Full_Paper-1.pdf
11. Kannan, K., Srivastava, R. C. S., Mohanty, M. and Sahoo, N., *Indian J. Soil Conserv.*, 2004, **32**, 225–227.

ACKNOWLEDGEMENT. This note is taken from the S.K.'s Ph.D. thesis entitled 'Economics of soil and water conservation: a case study of drought prone areas of Karnataka' with research conducted at the Division of Agricultural Economics, ICAR-Indian Agriculture Research Institute, New Delhi and funded by National Agricultural Higher Education Project (NAHEP), Indian Council of Agricultural Research, New Delhi (Grant No. NAHEP/CAAST/2018-19/07).

Suresh Kumar and Rajesh Bishnoi are in the ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Koraput 763 002, India; D. R. Singh is in the ICAR-Indian Agricultural Research Institute, Pusa Campus, New Delhi 110 012, India; M. Madhu is in the ICAR-Indian Institute of Soil and Water Conservation, 218 Kaulagarh Road, Dehradun 248 195, India.*
**e-mail: skdagri@gmail.com*

Engineering apomixis in rice

P. Kaushal, A. K. Roy and D. R. Malaviya

Apomixis, a natural mode of clonal reproduction through seeds, has a vast potential to revolutionize agriculture by virtue of its capacity for fixation of hybrid vigour, and is regarded as a next-generation breeding strategy[1]. Although widespread in the plant kingdom, natural apomixis is generally absent in agriculturally important crops. Hence, efforts are being made to introduce apomixis in agriculturally important crops through strategies such as introgression and mutation[2].

An 'evaluation and synthesis' approach has been followed to understand and induce apomixis in important crops in recent years[1,3]. The evaluation approach had generated information on genetics and molecular biology of apomixis based on studies conducted in natural apomictic systems (such as *Paspalum*, *Pennisetum*, *Panicum*, *Cenchrus*, *Tripsacum*, *Taraxacum*, *Hypericum*, *Hieraceum*, *Eragrostis*). This knowledge is being utilized for synthesis of the phenomenon in otherwise sexual systems, such as rice and *Arabidopsis*. In contrast to sexual reproduction which follows the double-fertilization process of syngamy between meiotically reduced male gametes with reduced egg cell and polar nuclei to generate viable embryo ($2n$) and endosperm ($3n$), it is now well understood that the process of apomictic reproduction essentially involves three components, viz. apomeiosis (formation of unreduced female gamete), parthenogenesis (development of egg cell without fertilization) and functional endosperm development[4]. Molecular progression of these components generates meiotically unreduced ($2n$) egg cells to develop without fertilization, thereby bypassing meiotic crossing-over and fertilization events – the two stages of creating variability – eventually leading to development of a clonal embryo[1,4]. Furthermore, in contrast to earlier reports suggesting a major locus control of apomixis, the three components have recently been demonstrated to be under the control of independent gene(s) and capable of partitioning (uncoupling) through recombination in neo-polyploid apomicts[5]. Their independent inheritance has also been demonstrated along with the potential that apomixis phenotype can be reconstituted when individual components are combined into the same genetic background. It was also discovered that apomictic and sexual reproduction are non-mutually exclusive and represented by closely related developmental pathways which rely on deregulation of the timing of reproductive events rather than on the alteration of a specific component of the reproductive pathway[1].

Comparative genomics (structural and transcriptomics) between apomictic and sexual forms had generated important insights into the identification and expression of key genetic elements involved in reproduction forms[5]. This has enhanced the probability of success in identifying potential genes from sexual systems to generate individual mutations that mimic phenotypes of partitioned apomixis components. Disrupted functions of these genes may generate (although with variable penetrance and expressivity) unreduced female gametes (through non-reduction) as well as develop the embryo and endosperm without fertilization. A compilation of such potential genes, both from natural apomictic and sexual systems, has been extensively presented in recent reviews[6,7]. A combination of these individual mutants was successful in generating apomixis-like phenotype in *Arabidopsis*, wherein meiotically unreduced egg cells were generated by *dyad* or *MiMe* mutations followed by selective elimination