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Organic manures drive soil productivity transitions in Himalayan range

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ABSTRACT

Farmyard manure (FYM)- mixture of animal dung, crop residues, urine, bedding material, fodder residues, household waste and other components - links crop, livestock, and forests to support livelihoods in mid-hills of Nepal. The practice was efficient under low intensity cropping systems for decades but, since 2000s, studies show deficiencies leading to decline in soil quality affecting land suitability for a range of crops. Farmers are aware of soil quality (field fitness), which guides crop choice. As farmers allocate resources towards improving crop and animal production, closing the nutrient cycle through improved utilisation of FYM is the most critical entry point in mixed farming system. Yet, in many parts of mid-hills, existing practices affect manure quality, which range from materials included, composting method, soil quality, landscape suitability, and method of application. FYM preparation and application are labour intensive. Most farmers keep FYM on an open pile or heap, some in an open half heap/pit, and a few in either an open or covered pit. Farmers use doko (approximately 25 kg) to transport to the field when considerable amount is accumulated weeks or months in advance and incorporate during land preparation after rainfall onset. This traditional practice expose manure to sunlight and rain resulting in volatilisation of nitrogen and runoff. Agent-based modelling is used to evaluate farmers' agency decisions to distribute FYM and choice of crops based on resulting soil suitability gradients to steer farms towards sustainable organic pathway. FYM improve soil fertility, soil structure, soil moisture, and tillage operations but to improve crop yields, farmers increasingly apply inorganic fertilisers at the expense of soil quality with significant environmental, economic, and social synergies and trade-offs.

Keywords: *Farmer agency, farm productivity, farmyard manure, Himalayan Range, resource recovery*

Background

The Himalayan region relies on farmyard manure for maintaining soil fertility over the long term and improve agricultural resilience of these fragile mountainous area. In Nepal, annually, 65.7 million tons of organic manure are generated from a diverse range of livestock, including cattle, buffalo, yak, goats, sheep, pigs, and poultry. This report explores how these organic manures enhance soil productivity and delves into their broader environmental and economic impacts. The Mid-Hills region, with its steep, terraced landscapes, is better suited for goats, which thrive in the challenging terrain, while cattle and buffalo are present in limited numbers on smaller land holdings. In this region, manure is primarily used to fertilize terraced farms.

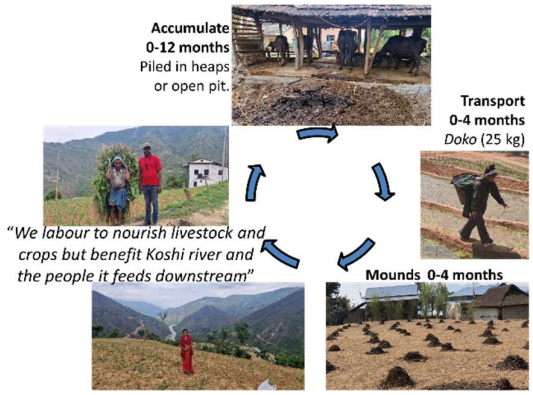
The traditional practice of collecting and applying manure was efficient under low-intensity cropping systems for decades but, since 2000s, studies show deficiencies leading to decline in soil quality and crop productivity (Pilbeam et al., 2005).

Farmers are aware of soil quality (field fitness) and use over 60 indicators relating to soil characteristics, crop performance, management, environmental and biology which correspond to laboratory measured soil fertility (Desbiez et al., 2004). There is an increasing effort to use animal manure with significant improvements in soil organic carbon and N but inconsistent effects on P and K (Bishwakarma et al., 2015). However, decrease in use of farmyard manure is experienced in some parts of the mid-hills of Nepal (Raut et al, 2011). Across mid-hills of Nepal, the Sustainable Soil Management Programme provided learning platforms for proper preparation and utilisation of organic manure between 1999 – 2014.

Farmer agency

As farmers allocate resources towards improving crop and animal production, closing the nutrient cycle through improved utilisation of FYM is the most critical entry point in mixed farming system. Yet, in many parts of mid-hills existing practices affect manure quality, which range from materials included, composting method, soil quality, landscape suitability, and method of application.

FYM preparation and application are labour intensive. Most farmers keep FYM on an open mound, some in an open half pit and a few in either an open or covered pit (SSMP, 2012a). Farmers use *doko* (1 doko = approximately 25 kg) baskets to transport to the plot when considerable amount is accumulated weeks or months in advance and incorporate during land preparation after rainfall onset. This traditional practice expose manure to sunlight and rain resulting in volatilisation of Nitrogen and runoff (SSMP, 2012b). Mechanisation would have freed labour but studies have shown that as much as animal ownership support use of farm-yard manure, it reduces likelihood of mechanisation (Chaudhary et al., 2022).



In mid-hills with low mobility, farmers use locally available resources and reconstituting the FYM is limited. The government is supporting farmers to improve composting and manage livestock shed. Soil quality and landscape attributes such as exposure could significantly influence volatilisation and affect manure quality. Time and method of manure application is depended on other resources and available technologies.

Farmyard manure and soil fertility

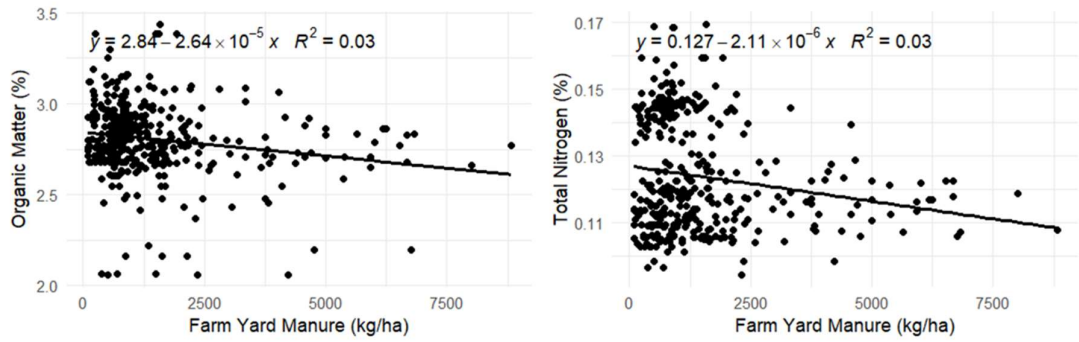


Figure 1Farm yard manure input and its contribution to organic matter and soil nitrogen in Mid-hills of Nepal.

Studies have established that FYM increases soil organic matter from 3.3% to 3.8% (Bishwakarma et al., 2015), soil fertility, structure, moisture and tillage (Pilbeam et al., 2005). crop yields by 25% (Satyanarayana et al ., 2002). However, results from mid-hills show that amount of manure applied is not associated with soil organic matter and total nitrogen content (Figure 1). However, soil quality is significantly influenced by topography (Figure 2).

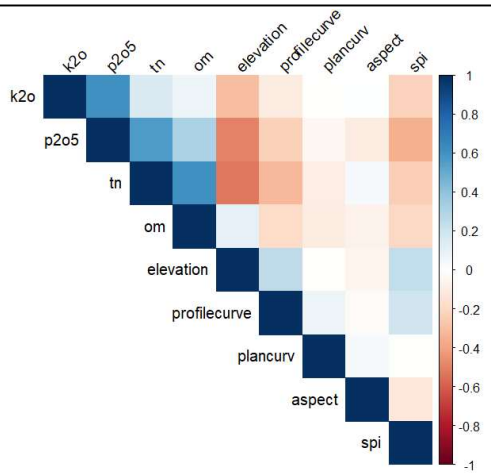
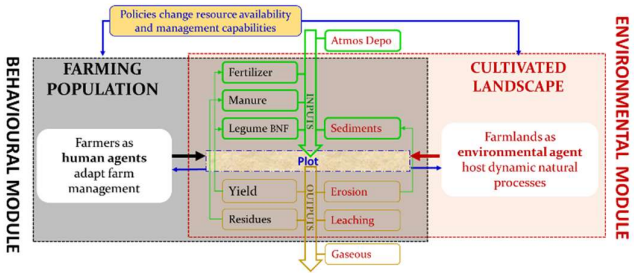


Figure 2 Soil quality (nitrogen, phosphorus, potassium and organic matter) influenced by topography in mid-hills

Next steps

Evaluate Human-Environmental systems dynamics in collaboration with government of Nepal's National Agricultural Research Council (NARC), the Local governments and local and international Universities such as Wageningen University Research). Understand nutrient input socio-economic decisions, the resulting soil productivity gradients and productivity of major cereals and opportunity crops, and simulate potential entry points for co-volution of Human-Environmental systems (Mponela et al., 2023).



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