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Sustainable integrated farming systems (SIFS) as biodiversity refugia: comparative analysis of ecosystem service providers across farming systems in subtropical India

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Abstract

Despite being a significant global food producer, India has two distinct challenges: food insecurity and climate vulnerability. The Sustainable Integrated Farming System (SIFS) strategy combines many agricultural components to enhance biodiversity interactions, reduce external inputs, and improve resource recycling. This study looks at biodiversity as a major indicator of ecosystem services where climate vulnerability is assumed to increase when biodiversity decreases. Study sites included 30 smallholder farms in West Bengal and Rajasthan, representing three farm categories: Old SIFS farms (>5 years implementation), new SIFS adopters (<3 years implementation), and conventional farms with application of mineral fertilisers and chemical pesticides. Each location included 15 farms (5 of each category), allowing for comparative analysis across farming system types and agro-ecological zones. Using approved ecological sampling procedures, we assessed the abundance and diversity of birds, natural predators (arthropods), pollinators (bees), and wild flora (herbs). The results show statistically significant differences in ecosystem service providers between agricultural systems. Bee abundance was greater (Kruskal-Wallis test $p < 0.05$) in old SIFS farms (mean=23.40) than in young SIFS (mean=12.90) or conventional farms (mean=12.00). Spider populations also varied (Kruskal-Wallis test $p < 0.05$), with old SIFS farms having the highest numbers (mean=34.80), followed by young SIFS (mean=29.60) and conventional systems (mean=17.80). Avian populations differed considerably, with old SIFS farms having the highest overall bird abundance (mean=68.30), followed by young SIFS (mean=60.40) and conventional farms (mean= 55.30). Avian frugivores were more common in old SIFS farms (mean=5.70) than in young SIFS (mean=5.40) or conventional farms (mean=2.50). Furthermore, SIFS consistently supported more ecosystem service providers, albeit not significantly, such as pollinator visitation, which were higher at SIFS (mean = 29.8 and 35.9 in old and new SIFS, respectively) than at conventional farms (mean= 19.5), and larger natural predator populations. Regional differences existed across research sites, with farms in West Bengal usually sustaining higher biodiversity than farms in Rajasthan. However, the increase in biodiversity following the implementation of SIFS

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was consistent in both areas. These findings provide empirical evidence that SIFS techniques improve biodiversity and ecosystem services, which are essential for climate resilience, and provide biodiversity refugia in simplified agricultural landscapes.

Keywords: Biodiversity refugia, climate resilience, ecological intensification, integrated farming, pollinators, sustainable agriculture