Original Research Article

Enhancing the efficacy of National Action Plan on Climate Change through Traditional Ecological Knowledge based practices of Agricultural Waste Management:Qualitative Insights from India

ABSTRACT

Agricultural waste management is a significant challenge in the context of climate change and environmental sustainability. However, Traditional Ecological Knowledge (TEK) has fostered effective resource management culturally over the years among farmers. But still there is a lack of research on how traditional ecological knowledge based practices can contribute towards climate action policies with respect to resource management. In this context, the current qualitative study was undertaken to assess the potential of indigenous/ traditional agricultural waste management practices in promoting resource sustainability and climate resilience, thereby analysing their ability to enhance the efficacy of the National Action Plan on Climate Change (NAPCC) in India. The research was carried out in three states of India, namely Haryana, Andhra Pradesh, and Tamil Nadu. A total of 11 farmers were selected through purposive random sampling and interviewed in-depth using semi-structured questionnaires, out of which the responses of 9 farmers were included in the final data, after screening. Proper qualitative analysis of the data using thematic analysis method revealed that the farmers commonly preferred and adopted in-situ, location-specific traditional practices for agricultural waste management, thus ensuring better resource optimisation and sustainability. The findings emphasized the integration of modern and traditional practices of agricultural waste management, combined with community-based initiatives, to better achieve the objectives of NAPCC. The insights suggested that promotion of traditional practices of agricultural waste management requires better incentives for farmers, more community based interventions by the government, and participatory decision-making with multiple stakeholders. Government policies like NAPCC should incorporate traditional ecological knowledge based practices with community involvement to promote sustainability, strengthen climate resilience, thereby fostering a stronger policy framework.

Keywords: Agriculture,Climate policy, Climate resilience, Community development, Sustainability, Waste management, Traditional ecological knowledge

1. INTRODUCTION

Climate change has been the most dreadful threat that the world is facing at the moment, with its impact being faced across all domains of terrestrial life on earth. It is defined as the significant shift in climate and meteorological patterns, at micro and macro-level, due to the effect of human induced activities, ultimately leading to resource degradation and environmental pollution (WMO, 1992).

Global warming, in itself, has become an antecedent as well as an outcome of climate change (IPCC, 2013; Hansen *et al.*, 2006; Shakhova*et al.*, 2010). In recent years, anthropogenic activities have led to about 1.0°C of global warming above pre-industrial levels, and if current emission trends continue, this increase could reach 1.5°C between 2030 and 2052 (Fawzy *et al.*, 2020).

Over the years, several natural hazards across the globe, all induced by global warming, haveseverely impacted sectors like food, agriculture, water, health, ecosystem, human habitat and infrastructure (Fawzy*et al*., 2020).Marginalised sections across the globe, including socio-economically disadvantaged groups, indigenous people, farmers, coastal communities, people from the drylands, and least developed countries are disproportionately affected by such havocs (IPCC, 2018).

In the domain of agriculture especially, farmers have been facing the wrath of climate changesince a few years now. Climate change has led to reduction in yield of crops, increased proneness to disease and pest attack, as well as reduced resistance of crops to environmental stress (Challinor *et al.*, 2014; Bebber *et al.,* 2013; Gregory *et al.,* 2009; Zandalinas*et al.,* 2018; Lesk *et al.,* 2016).

However, despite immense technological innovations prevalent in agriculture, waste management still remains a grave issue. Improper waste management in agriculture leads to degradation of soil quality (Lal, 2015), contamination of water (Vitousek*et al.,* 2009), and biodiversity loss as well (Potts *et al.*, 2010; Geiger *et al.,* 2010), all of which ultimately contribute to the detrimental effects of climate change.

Therefore, adverse effects of agricultural waste on the economy, environment and society disposes it as a significant issue of global concern (Capanoglu*et al.,* 2022) as reflected in the Sustainable Development Goals (SDGs). Ensuring environmental sustainability requires reducing agricultural waste, which in turn lowers production costs and improves food system efficiency (FAO, 2021). Despite efforts to implement adaptation and mitigation strategies based on western knowledge and technologies, these solutions often remain unaffordable for local communities. As a result, improper waste management in rural areas continues to harm the environment. Conventional strategies of waste management often overlook the significant potential of indigenous/traditional knowledge systems in managing resources, thereby perpetuating the divide between nature and culture.

Environmental policieshave a major role in recognising the importance of such traditional practices of resource management, thereby deepening the commitment of the society and the community in mitigating climate change (Berkes *et al.,* 2000; Magni, 2017).

The National Action Plan on Climate Change (NAPCC), launched by the Government of India on 30th June 2008, is one such climate sensitive environmental policy that strengthens the commitment towards climate change adaptation (GOI, 2008).It outlines a comprehensive strategy that integrates ecological sustainability with India's development goals. The primary missions focusing on climate adaptation and promoting sustainability, include:

1. National Solar Mission
2. National Mission for Enhanced Energy Efficiency
3. National Mission on Sustainable Habitat
4. National Water Mission
5. National Mission for Sustaining the Himalayan Eco-system
6. National Mission for a Green India
7. National Mission for Sustainable Agriculture
8. National Mission on Strategic Knowledge for Climate Change

The NAPCC seeks to safeguard vulnerable populations by promoting an inclusive and sustainable development approach that accounts for the impacts of climate change. It emphasizes the importance of reducing people's susceptibility to climate-related risks to improve their quality of life (Press Information Bureau, 2021).

With climate crisis endangering food security, the NAPCC has laid out a comprehensive plan to ensure climate resilience in the domain of agriculture. The National Mission for Sustainable Agriculture (NMSA), one of the eight national missions under NAPCC, aims to sustain agricultural growth through conservation and sustainable use of key resources, thus paving the way for sustainable and climate smart agriculture (Ministry of Agriculture, 2010). With a special emphasis on soil and water conservation, water use efficiency, soil health management and rainfed area development, the mission aims to foster sustainable agriculture through location specific measures, promotion of eco-friendly and energy efficient technologies, and synergizing resource conservation.

The National Mission for Sustainable Agriculture aims to foster location and crop specific soil health management by promoting integrated nutrient management, residue management, organic farming, development of soil fertility maps, efficient practices of decimating soil erosion etc. It incorporates a platform to develop and disseminate knowledge related to climate-smart sustainable agricultural practices, hosted by the Climate Change and Sustainable Agriculture: Monitoring, Modelling and Networking Program (CCSAMMN) (Department of Agriculture and Cooperation, 2014).

The ideas of climate-resilient cropping, climate-smart agricultural practices, optimised and sustainable use of agricultural resources, and reducing energy consumption in agriculture through private-public partnerships are relevant, but still there is a need to strongly address issues related to agriculture (Pandve, 2009).

Unfortunately, there is a lack of recognition and funding for promotion of traditional ecological knowledge among the farmers, which could have fostered better climate adaptation in agriculture, especially in the context of efficient resource management. There is a serious need for better incorporation of local communities and their knowledge in climate action (Rattani, 2018).

Indigenous/ local communities engaged in farming around the world have accumulated traditional ecological knowledge (TEK) across generations (Siragusa and Arzyutov, 2020; Madonsela*et al.*, 2024)and it has evolved adaptively too, thereby streamlining efficiency and resilience in farming (Berkes, 2012; Nakashima *et al.*, 2012).

Traditional Ecological Knowledge (TEK)refers to the collective knowledge, beliefs, traditions, practices, institutions, and worldviews that are cultivated and preserved by indigenous, peasant, and local communities through their interactions with the biophysical environment. This knowledge system, developed in harmony with socio-ecological dynamics, greatly enhances a community's resilience to environmental changes and improves their livelihoods (Gómez-Baggethun*et al.,* 2013).

Rasmussen (2023) emphasized the significant role of Traditional Ecological Knowledge (TEK) in uncovering the root causes of biodiversity loss, ensuring its conservation, enhancing socio-ecological resilience, building a culture of climate adaptation and mitigation. The vital role of traditional ecological knowledge in climate adaptation, mitigation, and resilience has also been acknowledged by

international organizations such as the Intergovernmental Platform on Biodiversity and Ecosystem Services and the Convention on Biological Diversity (Gómez-Baggethun*et al.,* 2013).

Intrinsically,practices based on traditional ecological knowledge are adaptive, diverse, nature-friendly and productive (Fernandez, 1994).Considering the issue of aggravating climate change and environmental degradation owing to improper management of agricultural waste (Mekonnen *et al.,* 2020; Singh *et al.,* 2021), it is evident that sustainable waste management in agriculture is the need of the hour.In this context, application of traditional ecological knowledge in agricultural waste management can prove to be beneficial in the long term as it promotes sustainability and also incorporates SDG-13 (Climate Action) goal of United Nations Sustainable Development Goals (Patel *et al.*, 2020).

Across the world, various traditional practices of agricultural waste management can be observed like the composting of crop residue in South Africa, reusing crop waste as animal feed/farm yard manure and reusing crop residues as inputs in multiple farming systems in many countries including Canada, Mexico, Nigeria, and Vietnam (Rabonda, 2023; Ajibade, 2007; Assuah, 2023; Taboada-González *et al.,* 2011; Tran *et al.*, 2020).

In India, most of the crop residues from farming are used for on-farm and off-farm activities. Use of farm residues like paddy stubbles for mulching, in-situ incorporation of paddy residues in the soil, use of crop residues for making farm yard manure, use of wheat straw as livestock feeds, use of cow dung as compost for crops and as domestic fuel, use of crop residue in integrated crop-livestock farming systems are some of the traditional practices of waste management that have fostered sustainability over the years (Singh *et al.,* 2020; Singh *et al.,* 2016; Sidhu and Beri, 2005; Singh and Singh, 2001). The experience of farmers practicing such traditional means of waste management suggests of improved soil quality, soil health, soil fertility as well as higher crop yields thus enhancing resilience (Kumar *et al.,* 2015; Veeresh *et al.,* 2011).

These indigenous/traditional practices of agricultural waste management help in achieving sustainable food production systems (SDG-2), combating climate change and its impacts (SDG-13), all helping in the achievement of the United Nations Sustainable Development Goals (Kumar *et al.*, 2021).

Thus, traditional ecological knowledge based practices of agricultural waste management need to be converged into the broad scope of National Mission for Sustainable Agriculture (NMSA) under Mission-7 of National Action Plan on Climate Change (NAPCC), which would further enhance its efficacy (GOI, 2008). Use of such traditional practices of agricultural waste management can provide more socio-ecologically sustainable solutions in the context of climate change.

With the above background, it is clear that despite the use of various technology backed interventions, agricultural waste management in India needs the inclusion and promotion of traditional ecological knowledge based practices, which would help in shaping a sustainable and ecologically sound agricultural ecosystem. Although environmental policies have been formulated to combat the harmful climatic outcomes of improper waste and resource management in agriculture, yet there is a lack of holistic incorporation of traditional ecological knowledge based practices in agricultural waste management at a community level, considering the fact that such traditional practices have proved to be sustainable, climate resilient, culturally sensitive, and community centric over many years.

In light of the above context, the current study was undertaken with an aim to explore the potential of traditional ecological knowledge based practices of agricultural waste management of farmers in enhancing the efficacy of the National Action Plan on Climate Change (NAPCC), with a focus on promoting sustainable resource management and fostering climate resilience and adaptation.The concerted effort in bringing forth the traditional principles of resource sustainability especially in terms of agricultural waste management shall not only aid in identifying conceptual/methodological advancements for NMSA but also in realizing NAPCC's principle of "Protecting the poor through an inclusive and sustainable development strategy, sensitive to climate change" (GOI, 2008).

2. MATERIALS AND METHODS

The study was undertaken using qualitative research design, by means of in-depth interviews to identify core practices/themes of traditional waste management among farmers that could potentially enhance the acumen of the NAPCC. The research question around which the study was centered is as follows:

" How can indigenous/traditional practices on waste management inform/contribute to NAPCC? "

The interview questions that were used to collect data have been listed in Table 1.Documents, case studies, government reports, pertinent policy documents and various other secondary data sources were examined in addition to primary data. This was done to comprehend the outcomes, policy consequences, and institutional frameworks that are recorded in sustainable resource management techniques. This would reflect various geographic contexts and conservation strategies.

Table 1. Interview Questions

Sl. No.	Interview Questions
1.	Tell us about your experience of waste management and challenges faced in dealing with the process?
2.	Tell us about your indigenous/traditional practices of waste management.
a.)	How do you incorporate them in your daily farming?
b.)	Do you recycle waste like generating organic compost?
3.	In your opinion, how does traditional practices help in sustainable waste management?
4.	What indigenous/ traditional strategies do you use to promote waste management at a community level?

The locale of the study includedthe villages of Shimla Maulana in Haryana, Seetharama Puram in Andhra Pradesh, and Nallampatti and Thumbathulipatti in Tamil Nadu, so as to un-earth the traditional practices in context of various geographies and conservation strategies. The details of the samplingprocedure are given in Table 2.

Table 2. Sampling Procedure

Name of the state	Name of the district	Name of Gram Panchayat	Name of village	No. of respondents
Haryana	Panipat	Shimla Maulana	Shimla Maulana	3
Andhra Pradesh	Chittoor	BalinaiduKandriga	Seetharama Puram	3
Tamil Nadu	Salem	Mooduthurai	Nallampatti	3
		VeerapandiyaPattam	Nallampatti	
		Perumapatti	Thumbathulipatti	

The sampling frame consisted of rural farmers who were selected by means of purposive random sampling (Tongco, 2007).The sample size was determined by means of theoretical saturation (Morse, 1995). Each interview respondent was assigned a code ranging from P1 to P11 (“P” for Participant”).

A total of 11 in-depth interviews in the respective local languages lasting an average of 29.5 minutes were initially conducted with the farmers until theoretical saturation(Morse, 1995) was achieved. The interviews were conducted, as depicted in Figure 1 and 2. The experiences, views, opinions on traditional resource management of the respondents were extracted using semi-structured questionnaire, consisting of open-ended questions. The audio responses with prior consent were recorded in mobile phones and subsequently, transcribed (local language to English) using verbatim transcription (Halcomb and Davidson, 2006) thereby ensuring accuracy and authenticity. Owing to voice overlaps and difficulty in comprehension, 2 interviews were considered unsuitable for transcription and hence, were excluded from the study. Thus, 9 interview responses were included finally. The interviewees candidly expressed their emotions, aspirations, challenges, and concerns thus providing useful insights into local conservation initiatives and socioeconomic factors that affect their choices.

Fig. 1: Interview with farmers at Seetharama Puram in Andhra Pradesh

Fig. 2: Interview with farmers at Shimla Maulana in Haryana

Data analysis, a key component of qualitative research, was conducted in accordance with the Thematic Analysis Method developed by Braun and Clarke (2006), that aids in efficiently identifying recurring patterns in qualitative data. The data was analysed in the following manner.

1. Familiarizing with the Data: Audio interview transcripts were repeatedly verified against the original recordings to ensure accuracy, followed by a thorough screening to gain an overview of the relevant data.

2. Generating Initial Codes: To systematically classify the data, key concepts were identified and manually coded using descriptive coding method (Saldaña, 2009; Miles *et al.,* 2014).

3. Looking for Themes: To uncover key trends in the data, codes were initially grouped into categories, such as “preference for traditional ecological knowledge based waste management” and “integrating modern and traditional ecological knowledge of waste management”. These categories were subsequently refined into coherent themes, guided by the alignment and interconnectedness of the underlying ideas. To ensure these themes accurately reflected the experiences of farmers and their engagement with traditional ecological practices, they were verified against the full dataset. Finally, themes were synthesized into a narrative using farmers' statements and document excerpts, illustrating trends and their significance for sustainable resource management.

4. Policy Analysis and extrapolations: Detailed policy documents on NAPCC and NMSAwere examined thoroughly along with government reports and additional policy documents to identify potential loopholes and opportunity for incorporation of traditional ecological knowledge.

The data analysis was followed by interpretation of results and their further discussion.

3. RESULTS

The present study unveiled various aspects of agricultural waste management with regards to the practices adopted by the farmers and their potential in contributing towards mitigating climate change.The insights signified the prevalence of in-situ waste management using traditional ecological knowledge, preference for adopting traditional practices of waste management, thereby pointing towards an integration of modern and traditional practices of waste management. Increased emphasis on the crucial role of government incentives, encouragement and community involvement in adoption of traditional ecological knowledge (TEK) based waste management in agriculture among the rural farmers under study. This suggested that even in the growing phase of modernisation of technologies, traditional practices of waste management have stood the test of time, and have been used by farmers since ages, along with the simultaneous use of modern practices. A comprehensive and rigorous analysis of the collected interviews generated three unique, yet inter-related themes, namely, (i) Preference and adoption of TEK-based in-situ waste management practices leading to more sustainability*(Fig. 3)* (ii) Integration of modern and TEK-based waste management practices *(Fig. 4)*(iii) Government incentives and community driven approach for better adoption of TEK-based waste management*(Fig. 5)*.

With the traditional ecological knowledgedeeply ingrained in their daily life, most of the farmers preferred and adopted traditional practices which were based on in-situ waste management. Use of paddy straw as crop manure for subsequent crops through decomposition in the pit followed by its incorporation in the soil was highly practiced among all respondents, as is evident from the testimonies.

"*Earlier people used to rot the straw by putting it in a pit and after 6 months or a year they used to turn it over in the field." (P4)*

"Yes that is recycle means……dig into 10 to 15 feet breath and 30 to 35 feet length and collected these wastes and add the waste composers with them that leads to degrades……. Then, we collect it and used for next yield corps…….we add to this kind of compost to brinjal and tomato plants." (P9)

Paddy straw was also used as animal feed by most of the farmers, which helped in optimising the resources. Many farmers adopted other traditional practices like preparing compost made of vegetable waste, cow dung. Vermicompost based manures were predominantly used by the farmers, in addition with cow dung, vegetable wastes, crop residues being managed in-situ. This has been reflected by respondents.

"I practice this manure method called vermi -compost, animal manure and cow dung. With 2 cows,we can easily manage farmland with the required manure." (P1)

"Basically, the Earthworms are considered as Farmers Friends. Because, these earthworms ……..When we follow the organic farming, these earthworms are grow into higher counts in our land." (P7)

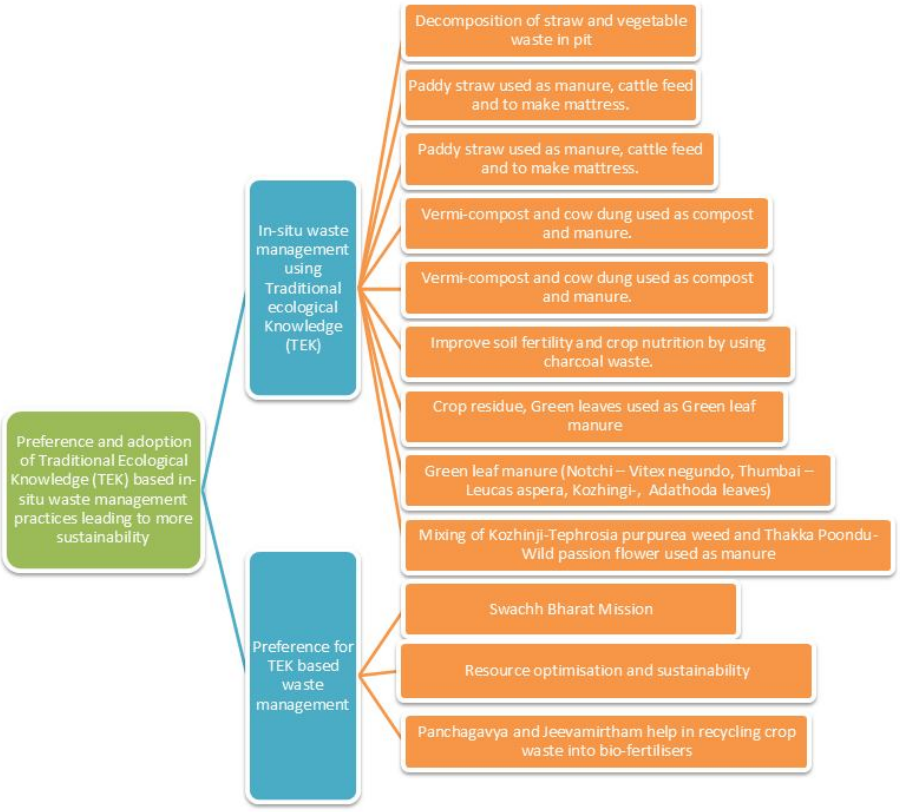

Fig. 3: Theme 1 for Traditional Waste Management Practices; Boxes in Orange representCodes, those in Blue represent Categories/Sub-themes and that in Green represents the theme.

Interestingly, some age-old practices have been passed on as a legacy across generations, among the rural farming community of specific regions. Traditional cisterns are still being used by farmers for waste collection from the field, and further incorporation into the field itself.

"Our ancestors used to make cistern for collecting waste..This waste used to become fertiliser and they use it in their field." (P6)

In some specific communities, crop residues along with green leaves were utilised by farmers as "Green Leaf Manure", with various indigenous herbs, shrubs, and leaves from plants being used to enrich the nutritive value of manure. Adoption of such practices enhance, strengthen and preserve the traditional ecological knowledge of the community for the future as well.

"I added many ingredients for my land for get more fertilizer by plants, herbs, shrubs, sanappai, Avarai, Thuvarai, Naripayaru, Green gram, Horse gram, all ingredient with Kambu, Solam, Ragi, Rice grain, Makka Cholam, " (P7)

"In the waste management, the traditional technique used the Notchi, Thumbai,Kozhingi, Adathoda and leaves from mountains and forest are used for fertilizer." (P7)

Weeds and crop residues found their place as ingredients of manure, very often used by the farmers of Tamil Nadu, especially for improving the nutrient content of the soil. Yadav *et al.* (2015) validated this in his study as well.

"Waste management means in early days like rice grain that surrounding weeds are used and "Thakkapoondu" mixture and then what are all the wastes comes from the yield are always return to that place and then textured that can help to yield better." (P9)

"We are using the "Kozhinji" weeds for making the efficient fertilizer by degradation method for our farming purposes." (P8)

This suggests that rural communities have since long been using TEK-based practices for managing agricultural waste, though there have been many shortcomings in the way.

With diffusion of better modern technologies and modern practices, the farmers did not completely abandon the traditional methods but rather adopted an integration of both modern and traditional approaches, aiming at hybrid techniques to sustainably and efficiently manage farm waste.

Fig. 4: Theme 2 for Traditional Waste Management Practices; Boxes in Orange represent Codes, those in Blue represent Categories/Sub-themes and that in Green represents the theme.

Using of rotavator in the field for removing waste, mixing organic waste including herbs, shrubs,crop residues, etc., with inorganic fertilizers to form manure for improving soil fertility, were some of the hybrid practices followed by farmers. Such practices helped them in efficiently managing their agricultural waste, as can be verified by the testimonies.

"I manage waste with the help of a rotator and it will act as a manure for the field."(P1)

"We used to make our own organic compost and animal manure,cow dung and rotator in our field." (P2)

"I added many ingredients for my land for get more fertilizer by plants, herbs, shrubs, sanappai, Avarai, Thuvarai, Naripayaru, Green gram, Horse gram, all ingredient with Kambu, Solam, Ragi, Rice grain, Makka Cholam, these ingredient into Pasunthal Fertilizer. This fertilizer has more strength to grow plants." (P7)

The interviews clearly reflected that the farmers often vehemently practised and advocated for TEK-based practices of waste management. The farmers reported increase in their efficiency, better optimisation of resources, agreement on sustainable farm returns, improvement in soil fertility, and these potentially were the major reasons that encouraged them to continue with the traditional practices of waste management.Neeraj *et al.* (2023) suggested the use of organic waste and crop

residues for enhancing soil fertility, as they enhance soil health and also ensure sustainable agriculture. This was further reinstated by Chew *et al.* (2019) and Hossain *et al.* (2017), as it was proved that organic waste when incorporated into the soil improved soil health, pest and disease resistance.

"They will surely not only help the farmland in achieving sustainability but also help us monetarily." (P1)

"It will surely help us financially as we need not buy the chemical made manure and also the yield is very productive through the traditional method only." (P3)

With specific preparations like Jeevamirtham and Panchagavya being made out of waste, these helped in restoring soil health, crop nutrition, and sustainability in farming.

"I used cow dung, cow urine, spoiled curd, ghee, banana and organic sugar and tender coconut water. I added all these ingredients to get Panchakavya preparation. This can give all essential nutrients." (P7)

"……..Jeevamirtham also I used……. When we need it immediately, we can use the Jeevamirtham. The 5 litre of Cow Urine, 5 litre of Cow Dung, 2 kg of Organic sugar and 2 kg of green gram ……When we mix these all ingredients and ……..then we can get the Jeevarmirtham. We mixed this mixture into water to sprinkle over the crops ……This provides more nutrients. These are all my recycling things from cow dung waste and spoiled fruit wastes." (P7)

The preference of respondents towards traditional practices, also faced various challenges which hindered the successful adoption of such practices of waste management. The testimony of participants like,

"…with 2cows,we can easily manage farmland with the required manure.But it's tough now as we don't have cows with us." (P1)

"Earlier we atleast used to get some subsidy in dealing with waste management,but now we are only buying manure and also that is not giving any proper yield like before" (P1)

suggested various challenges like lack of incentives by the government, lack of resources, lack of community-based initiatives, which needed to be addressed.

Nevertheless, the study highlighted the importance of government intervention and community mobilisation in popularising the adoption of TEK-based waste management practices. The farmers revealed the need for community driven approaches like community waste collection and recycling,

community mobilisation and awareness through meetings and workshops, community sharing of knowledge and expert consultation in community meetings, which would broaden the scope of traditional waste management adoption.

"At the community level,we had these agricultural meetings and anything of that sort if made for educating the farmers about the waste management strategies it would help farmers more." (P2)

"We can share our experience and knowledge with each other. we can make sharing community compost but in current time people don't show unity to each other and it becomes again problematic." (P6)

The respondents also advocated for provision of more incentives by the government, better ground level dissemination of policy related information to the farmers, efficiency in disbursement of incentives, and frequent monitoring by the government, which would collectively supplement the promotion of TEK-based practices of agricultural waste management.

"The government policies are only effective when they support farmers financially even when the farmer incur loss." (P2)

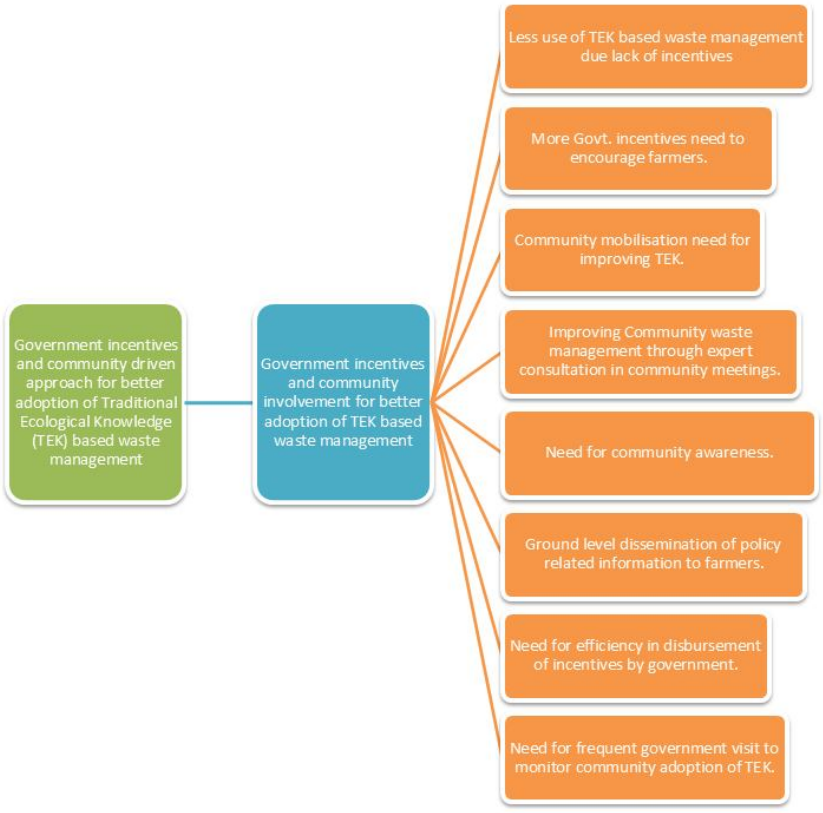

Fig. 5: Theme 3 for Traditional Waste Management Practices; Boxes in Orange represent Codes, those in Blue represent Categories/Sub-themes and that in Green represents the theme.

The findings thusrevealed that the widespread use of TEK-based waste management practices have definitely aided in achieving the goal of sustainable agriculture. These practices contribute to sustainability of environment, ecology and agro-ecological systems thereby helping to mitigate climate change (Sharma *et al.,*2023). Scaling up of these indigenous practices can build even stronger community values and beliefs for the future (Bhan *et al.,* 2016).Moreover, Smith *et al.* (2019) stated that the approach of integration of traditional and modern practices highlights the principles of resource optimisation and enhanced resilience, which is crucial in ensuring sustainable agriculture. This was also stated by Sharma and Pradhan (2021), Mendez *et al.*, (2018)and Ghosh and Das (2020).

As reflected from the insights of the participants, the government should develop and implement more community based holistic approaches which could help in efficient waste disposal and foster more participatory interventions to manage waste while mitigating climate change.Such practices will enhance community resilience, and leadership in achieving a sustainable and climate resilient agricultural system that forms part of a green economy (Berkes, 2012; Kumar and Pandit, 2013).

4. DISCUSSION

The majority of the traditional agricultural waste management techniques used in the rural communities under investigation are in line with NAPCC, particularly mission-7, i.e., the National Mission for Sustainable Agriculture (NMSA). The NMSA places a strong emphasis on sustainable methods in agriculture, to combat climate change and environmental deterioration. It supports sustainable land-use practices and soil health management, two areas to which TEK-based waste management techniques can make a substantial contribution. In this way, the research findingscontribute to the objectives of NMSA, which include lowering agricultural carbon footprints and enhancing soil health (Ministry of Agriculture, 2010).

The use of various traditional practices of waste management, add to the scope ofthe mission strategy of *"Popularizing resource conservation technologies (both on-farm and off-farm) and introducing practices that will support mitigation efforts….."* as highlighted in the NMSA policy, since such practices are already in use (Department of Agriculture and Cooperation).

The challenges of limited resources, labour, and incentives for adopting traditional practices can be addressed through an integrated approach that combines the strengths of both modern and traditional methods. The National Action Plan on Climate Change (NAPCC) also emphasizes the need for community-led climate efforts, particularly in agriculture, thus reflecting the scope of community driven approaches in popularizing traditional ecological knowledge (TEK) in waste management. Incorporating TEK into modern climate resilience strategies, especially through community-based initiatives, ensures that local solutions play a central role in tackling climate change (GOI, 2008).Traditional agricultural waste management practices, when supported by community-driven approaches, are crucial for advancing traditional ecological knowledge. These methods provide cost-effective and sustainable solutions, contributing to the goals of both the National Mission for Sustainable Agriculture (NMSA) and NAPCC. Combining traditional techniques with modern waste management fosters a more comprehensive and community-focused approach, empowering farmers to develop sustainable agricultural systems that support local ecosystems and broader environmental objectives.

5. CONCLUSION

The study highlights the preference and use of traditional ecological knowledge in agricultural waste management by the farmers across India. Despite the overwhelming presence of technological advancements, the application of traditional agricultural waste management through in-situ and community-based techniques can significantly ameliorate resource management and sustainability. Traditional ecological knowledge when merged with modern technology-oriented interventions, can significantly enhance the efficacy of the NAPCC and contribute to the discourse on climate action. Hence, there is a need to develop broader policy frameworks under the scope of NAPCC that not only promote hybrid systems but are democratic, inclusive and participatory thereby incorporating traditional/indigenous knowledge systems. Such holistic initiatives shall enhance productivity and socio-ecological resilience especially in times of climate change. Additionally, initiatives should be

taken under NAPCC to incorporate more community based interventions of waste management, centred around traditional ecological knowledge, along with provision of better incentives to the farmers, community mobilisation, awareness, and community sharing of knowledge, thereby collectively strengthening the policy framework of NAPCC and streamlining the commitment towards achieving a sustainable agro-ecosystem and resilient farming community.

This study has certain limitations, primarily due to its focus on a limited geographic area within three Indian states, which limits broader generalizations beyond the study's specific parameters. Additionally, like other qualitative research, this study may reflect some level of researcher bias, despite efforts to minimize ethnocentric influences. Given India's extensive biocultural diversity and range of traditional practices, future studies should adopt a broader geographic scope and an interdisciplinary approach, engaging experts like agronomists, anthropologists, environmental scientists, geographers, and other social scientists. Incorporating Geographic Information Systems (GIS) and remote sensing technology could further enhance data precision and offer valuable insights into the impact of traditional practices on soil and water conservation, waste management, and land use.

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ABBREVIATIONS

NAPCC: National Action Plan on Climate Change

TEK: Traditional Ecological Knowledge

SDGs: Sustainable Development Goals

NMSA: National Mission for Sustainable Agriculture

CCSAMMN: Climate Change and Sustainable Agriculture: Monitoring, Modelling and Networking

GIS: Geographic Information Systems