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Adoption and Compliance of AI-Enabled Pest Advisories: Evidence from the National Pest Surveillance System (NPSS) in Odisha, India

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HIGHLIGHTS

- NPSS advisories reached widely; only about half were converted into action.
- Adherence declines with increasing severity, especially for BPH and YSB in paddy.
- Simple, low-cost measures saw the highest compliance; input-intensive recommendations lagged.
- Paddy dominated sample; brinjal showed similar severity–adherence patterns.

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ABSTRACT

Artificial intelligence (AI)–enabled pest surveillance can bridge gaps between timely diagnosis and on-farm action in smallholder systems. This study assessed farmer exposure to and uptake of advisories from India's newly launched NPSS in Odisha. An exploratory, cross-sectional inquiry was conducted during 2024–25 across 30 districts; one block and two villages per district were purposively selected based on NPSS use. Data were gathered from 1,422 participants through focus group discussions and personal interviews, and analysed. Paddy dominated the sample's cropping pattern (66.17% of respondents), followed by brinjal (9.21%). Overall, 79.16 per cent were receiving NPSS advisories; the platform issued 851 advisories during the study, with 418 acted upon (49.11% adherence). Adherence declined as pest severity increased, especially for brown planthopper (BPH) and yellow stem borer (YSB) in paddy from 47.73 per cent (low severity) to 32.47 per cent (high severity), and YSB showed a similar drop (about 45.95% to 10%). Qualitative insights indicate lower uptake when recommendations involve costlier or more complex chemical controls, suggesting a need for clearer messaging, phased options, and enhanced last-mile support. The findings highlight substantial reach but moderate compliance, underscoring opportunities to tailor NPSS advisories to farmers' resource realities and to strengthen capacity-building for higher-severity scenarios.

INTRODUCTION

Timely and precise pest management remains a critical constraint in Indian smallholder agriculture, where losses from insects and diseases can undermine yields, quality, and profitability despite decades of technology diffusion (Singh & Gupta, 2016; Singh et al., 2015). Integrated Pest Management (IPM) has been

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promoted as an eco-friendly framework that emphasises cultural, mechanical, and biological tactics alongside need-based chemical use. However, adoption relies on credible, timely, and context-specific advice reaching farmers at scale. Digital advisory systems offer one pathway to bridge this "last-mile" information gap by accelerating diagnosis and tailoring recommendations to local conditions (Saha et al., 2024). Emerging global evidence suggests that such digital information interventions can improve input decisions and farm outcomes. However, their effectiveness varies with design and delivery.

In this context, the Government of India launched the National Pest Surveillance System (NPSS) on 15 August 2024 to strengthen real-time surveillance and deliver AI/ML-enabled crop protection advisories (Kumar & Nandeesha, 2023; Prusty et al., 2025). NPSS integrates field scouting, geo-referenced data flows, and expert validation to issue advisories through a mobile app and web portal, aiming to reduce dependence on pesticide retailers and promote scientific pest management (Suman et al., 2024). The platform was developed by the Indian Council of Agricultural Research – National Research Centre for Integrated Pest Management (ICAR-NCIPM) in collaboration with the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) and the Ministry of Agriculture & Farmers' Welfare (DA&FW). Early government reports indicate a phased roll-out and a growing user base, underscoring the need for independent assessments of advisory reach and farmer uptake across diverse agro-ecologies (Saha et al., 2025).

Odisha provides a relevant setting for such inquiry (Mwenda et al., 2023). Rice remains the state's dominant crop, central to both area and livelihoods-even as diversification gains traction; public statistics and recent surveys consistently mark paddy's prominence. In this context, rapid and credible advice on pest outbreaks-such as the brown planthopper in paddy or key pests in brinjal, can significantly influence farmers' control choices and timing. NPSS claims to facilitate accurate and efficient diagnosis and treatment guidance, positioning it as a potential catalyst for IPM-aligned decisions at scale (Suman et al., 2025). Given the novelty of NPSS and the limited empirical evidence on compliance with AI-enabled pest advisories in India, there is a clear gap: whether, and under what conditions, farmers act on such advisories.

METHODOLOGY

An exploratory, cross-sectional study was conducted in Odisha during 2024–2025 to investigate the use of the National Pest Surveillance System (NPSS) advisories and farmers' adoption rates. The study encompassed all 30 districts, from which one block and two villages were purposively selected based on the demonstrated use of the NPSS mobile application by farmers. The sampling frame consisted of NPSS-linked farming communities within the chosen villages, involving a total of 1,422 participants. Data collection involved focused group discussions (FGDs) and personal interviews, guided by an interview schedule aligned with the study's objectives. Field teams documented (i) exposure to NPSS (awareness, access, and receipt of advisories), (ii) advisory content and recommended practices, (iii) whether advisories were followed or not followed, and (iv) contextual factors influencing on-farm decisions. All responses were tabulated and analysed descriptively.

To contextualise advisory uptake within the production environment, the instrument recorded prevalent crop-wise cultivation in the villages. This approach allowed results to be summarised by major crops instead of solely at an aggregate level. Recognising the operational importance of severity cues in pest management, the study also documented the severity class associated with NPSS advisories (low/medium/high) for key crops, along with the recommended management practices. For paddy, advisory–practice pairs were noted for brown planthopper and yellow stem borer across all severity levels, with similar details recorded for brinjal pests. This data facilitated the computation of advisory compliance by pest and severity tier.

Data processing involved consistency checks and tabulation of frequencies and percentages by objective. No experimental treatments or inferential statistics were utilised; instead, the interpretation focused on pattern recognition-how compliance varied by crop, pest, and severity-and its practical implications for NPSS message design and last-mile support. The choice of an exploratory design with purposive selection of NPSS-using villages was suitable for a first assessment of advisory uptake under a newly launched public digital system and for generating actionable insights for extension practice. Future research may apply inferential statistics to test links between socio-economic variables and uptake.

RESULTS

In the surveyed villages, rice was the predominant crop, influencing the types of advisories provided and the options available for farmers to act on them. Among respondents, 66.17 per cent (n = 941 out of 1,422) cultivated paddy, significantly more than any other crop; brinjal was a distant second at 9.21 per cent (n = 131). Smaller percentages reported growing tomato (4.08%), chilli (3.31%), banana (3.16%), maize (2.88%), cotton (2.74%), and black gram (1.55%), with an "others" category comprising 6.89%. These crop distributions set the stage for understanding the subsequent findings on advisory flows and adherence (Figure 1).

Of the 1,422 NPSS-linked participants across 30 districts, 1,078 (75.80%) monitored pests during the reference period. During this time, NPSS issued 851 advisories, of which 418 were followed, resulting in an overall adherence rate of 49.11 per cent. This data indicated a significant generation and distribution of advisories, yet

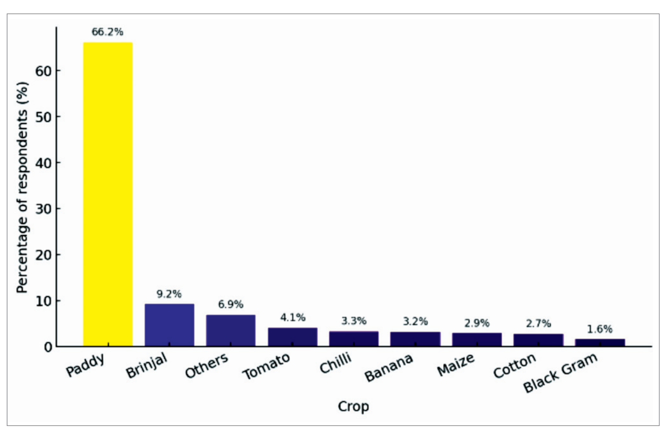

Figure 1. Distribution of major crops grown by respondents

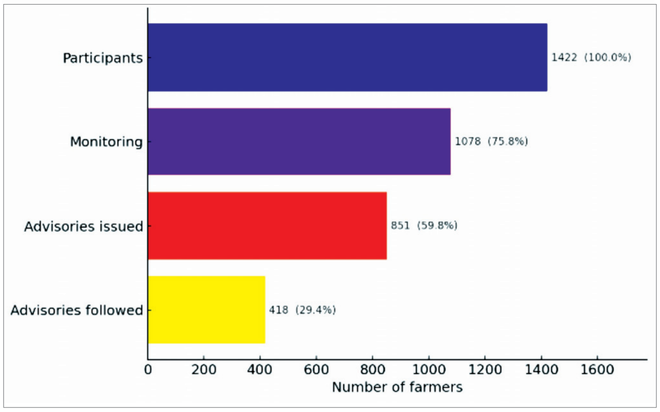

Figure 2. Advisory funnel showing participation, monitoring, dissemination, and adoption

only one out of every two advisories led to on-farm action (Figure 2). Examining the data by crop reinforced the overall findings. For paddy, 554 advisories were issued, with 251 followed (45.31%) and 303 not followed (54.69%). For brinjal, 97 advisories were issued, 42 of which were followed (43.30%), while 55 were not (56.70%). In both primary crops, fewer than half of the advisories issued resulted in action, suggesting that the complexity of the recommendations and situational constraints influenced the uptake of advice.

In paddy, adherence tended to decrease with the increasing severity of major pests, as recommended actions shifted from simple field operations to more specialised inputs. For the brown planthopper (BPH), nearly half of the advisories were followed at low severity (47.73%, 42 out of 88), but this dropped to 40.74 per cent (33 out of 81) at medium severity and further to 32.47

Table 1. Summary of pest management status of Paddy and advisory services followed by farmers

S.No.	Pest	Severity	Management practices issued by NPSS	Advisory issues by NPSS	Advisory followed farmers (%)
1	BPH	Low	Draining of water at 10-day intervals	88	47.73
		Medium	Spray neem based insecticide Azadiarachtin 1500 ppm @ 5 ml/lit	81	40.74
		High	Draining of water at 10 days interval spray pymetrozine 50 WG @ 300 g/ha or flonicamid 50% WG @ 150 g/ha or dinotefuran 20% SG @ 150 g/ha	77	32.47
2	Yellow stem borer	Low	Fixing of phermone trap @ 5 traps/ha Release of parasitoid Trichogramma Japonivum @ 1.5 lkh/ha (affixed as tricho cards)	37	45.95
		Medium	Spray neem based insecticide Azadiarachtin 1500 ppm @ 5 ml/lit	34	32.35
		High	Apply chlorantraniliprole 18.5% SC 150 ml/ha or chlorantraniliprole 0.4% GR or @10 kg/ha or Bifenthrin 10% EC @ 500 ml/ha or cartap hydrochloride 4% granules @ 18.5 to 25 kg/ha or cartap hydrochloride 50% SP @ 1 kg/ha, or fipronil 5% SC@ 1000 ml/ha	10	10.00
3	Gundhi bug	Low	Fixing of Light traps	15	26.67
		Medium	Spray neem-based insecticide Azadiarachtin 1500 ppm @ 5 ml/lit	14	21.43
		High	Imidacloprid 6% + Lambda-cyhalothrin 4% SL @ 300 ml/ha	5	40.00
4	False smut	Low	NA	25	100
		Medium	Spray Pseudomonas fluorescens @ 10 g/lit	36	13.89
		High	Spray Copper hydroxide 77% WP 2.5 g/litre	13	46.15
5	Bacterial leaf blight	Low	Drain water	14	100
		Medium	Drain water	12	100
		High	Spray Coper oxychloride 2 g/litre or Spray streptomycin sulphate 90% + Tetracycline hydrochloride 10% @ cycline 1 g/10 litre water. Avoid excessive use of nitrogenous fertilizer	3	0.00
6	Blast	Low	Flooding field	15	73.33
		Medium	Spray Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC @ 500 ml/ ha or	6	33.3
		High	Kasugamycin 3% SL @ 1000-1500 ml/ha	22	54.55
7	Brown spot	Low	NA	5	100
		Medium	Spray Pseudomonas fluorescens @ 10 g/litre	17	47.06
		High	Hexaconazole 5% EC(Contaf 5 EC) @ 1000 ml/ha or Azoxystrobin 120 g/L + Tebuconazole 240 g/L SC @ 830 ml/ha or Difenoconazole 10% + Mancozeb 50% WDG @ 625 g/ha	7	71.43
8	Leaf roller	Low	Release of parasitoid Trichogramma chilonis @ 1.5 lkh/ha	11	18.18
		Medium	Spray neem-based insecticide Azadiarachtin 1500 ppm @ 5 ml/lit	4	75.00
		High	Apply chlorantraniliprole 18.5% SC 150 ml/ha or chlorantraniliprole 0.4% GR or @10 kg/ha or Bifenthrin 10% EC @ 500 ml/ha or cartap hydrochloride 4% granules @ 18.5 to 25 kg/ha or cartap hydrochloride 50% SP @ 1 kg/ha, or fipronil 5% SC @ 1000 ml/ha	3	100
Overall pest management advisory services followed by farmers				554	45.31

per cent (25 out of 77) at high severity, where insecticides (e.g., pymetrozine, flonicamid, dinotefuran) were recommended alongside water management. This trend suggested that farmers preferred familiar, low-cost actions (such as periodic drainage) and were less likely to adopt chemical controls unless necessary (Table 1). A similar pattern was observed for the yellow stem borer (YSB). At low severity, adherence was 45.95 per cent (17 out of 37) with recommendations for pheromone traps and Trichogramma releases; this dropped to 32.35 per cent (11 out of 34) at medium severity, and fell to just 10.00 per cent (1 out of 10) at high severity, where a variety of insecticidal options (e.g., chlorantraniliprole, bifenthrin, cartap, fipronil) were suggested. The substantial decline in adherence at high severity highlighted how input-intensive recommendations were associated with the lowest uptake.

Other paddy pests exhibited mixed adherence profiles that reflected the severity–complexity relationship. For the gundhi bug, adherence was low at both low severity (26.67%, 4/15) and medium severity (21.43%, 3/14), with a slight increase at high severity (40.00%, 2/5). In contrast, all low-severity advisories for false smut were followed (100%, 25/25), but adherence dropped sharply at medium severity (13.89%, 5/36) before partially recovering at high severity (46.15%, 6/13). For bacterial leaf blight (BLB), straightforward drain-water advice achieved perfect adherence at both low (100%, 14/14) and medium severity (100%, 12/12), while high severity prescriptions involving copper oxychloride or antibiotic mixtures saw no uptake (0/3). Regarding blast, farmers adhered to low-severity nitrogen-management advice (73.33%, 11/15), but compliance fell significantly for medium flooding guidance (33.3%, 2/6) and reached 54.55 per cent (12/22) for high-severity fungicide recommendations. For brown spot, adherence was 100 per cent at low severity (5/5), 47.06 per cent at medium severity (8/17), and 71.43 per cent at high severity (5/7), with the latter coinciding with clear fungicide options. These variations indicated that simple, routine actions led to high compliance, while more complex or input-intensive recommendations faced challenges–except where farmers perceived clear, immediate benefits or had easy access to inputs.

In brinjal, the severity–adherence relationship mirrored that of paddy, with notable declines in adherence when advisories involved chemical controls or complex cultural practices. For thrips, farmers followed 45.45 per cent (20/44) of low-severity advisories focused on sticky traps and predator conservation; adherence dropped to 30.00 per cent (3/10) at medium severity and fell to 0 per cent (0/5) at high severity, where multiple insecticidal options were suggested. In the case of bacterial wilt, the low-severity recommendation of immediate rouging and destruction of infected plants achieved 91.67 per cent adherence (11/12), but adherence significantly declined at medium severity (30.43%, 7/23) and remained low at high severity (33.33%, 1/3) due to the greater effort and time needed for soil and rotation measures, along with perceived uncertainties regarding returns (Table 2). These findings suggest that, similar to paddy, the demands of the advisory—such as cost, complexity, and timing-strongly influenced uptake in brinjal.

The expanded results across crops and pests revealed three consistent empirical patterns. First, the platform demonstrated substantial reach across districts and crops, with half of the issued advisories leading to on-farm actions. Second, adherence generally decreased as severity increased, especially when recommendations shifted from low-cost field operations to specialised chemicals or multi-step cultural practices. Third, simple, actionable guidance garnered significantly higher compliance compared to recommendations that imposed higher upfront costs, greater technical specificity, or time-intensive operations. These patterns help explain why both paddy and brinjal showed less than 50% overall adherence despite high exposure to advice, setting the stage for a focused discussion on message design, sequencing of options, and last-mile support for more demanding recommendations .

DISCUSSION

The findings revealed an advisory system with considerable reach but modest action conversion, as only about half of the issued advisories led to on-farm implementation (Sagar et al., 2022). In a rice-dominant context, this result was not surprising; the centrality of paddy to livelihoods created a strong demand for guidance. However, the content, timing, and cost of recommended practices influenced whether the advice was acted upon (Das et al., 2025). A severity–adherence gradient was observed across pests and crops (Ganai et al., 2018; Khan & Damalas, 2015). As recommendations progressed from simple field operations to input-intensive chemical controls or multi-step cultural regimes, adherence generally decreased. This trend was most evident in paddy for yellow stem borer and brown planthopper, where high-severity advisories were least likely to be implemented. In brinjal, significant drops in adherence for thrips and bacterial wilt at medium to high severity indicated that costly or complex recommendations deterred uptake. Conversely, exception cases–such as perfect adherence to low-severity guidance for false smut and bacterial leaf blight–highlighted a preference for immediately actionable, low-cost practices that farmers viewed as feasible and effective.

Three mechanisms likely explained these patterns: (i) affordability and access, (ii) complexity and timing, (iii) perceived efficacy and risk (Kabir, 2015; Baliwada et al., 2017; Baliwada et al., 2018; Nain et al., 2018). Therefore, the severity drops in adherence appeared less as a rejection of advice and more as an indication of transaction costs that escalated with the intensity of prescriptions. These insights have actionable implications for digital advisory design and last-mile support (Ashokkumar & Naik, 2021). Message architecture could be restructured to present phased, costed options–labelled "Good/Better/Best"–with clear resource footprints (cost, labour, time) and expected benefits. For high-severity situations, advisories should emphasise the minimal viable action to stabilise losses, followed by graduated chemical choices with concise instructions and safety notes. Localisation is essential: tailoring product examples to locally available actives and pack sizes could ease procurement challenges. Channel blending–using push notifications in the app alongside voice calls/SMS for time-sensitive alerts–could expand reach to less digitally engaged users. Field demonstrations and peer endorsements (through farmer facilitators/FPOs) can mitigate risks associated with complex actions like using

Table 2. Summary of pest management status of Brinjal and advisory services followed by farmers

S.No.	Pest	Severity	Management practices issued by NPSS	Issued Advisories by NPSS	Advisory followed farmers (%)
1	Thrips	Low	Set up blue traps sticky traps 15 cm. above the crop canopy for monitoring and mass trapping of Thrips @ 10-20 traps per acre. Conserve predators such as green lacewings, predatory mites, and predatory thrips	44	45.45
		Medium	Spray Broflanilide 300 g/l SC @ 42-62 ml in 500 litre of water/ha or Fluxametamide 10% w/ w EC @ 400 ml in 500 litre of water/ ha or Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1250 ml in 500 litre of water/ ha or Diafenthiuron 48% + Dinotefuran 8% WG @ 625gm in 500 litre of water/ ha or Emamectin Benzoate 1.1% + Diafenthiuron 30% SC @ 1000 ml in 500 litre of water/ha or Fluxametamide 3.8% w/w + Pyridaben 9.5% w/w SC @ 1000 ml in 500 litre of water/ha	10	30.00
		High	Spray Broflanilide 300 g/l SC @ 42-62 ml in 500 litre of water/ha or Fluxametamide 10% w/ w EC @ 400 ml in 500 litre of water/ ha or Clothianidin 3.5% + Pyriproxyfen 8% SE @ 1250 ml in 500 litre of water/ ha or Diafenthiuron 48% + Dinotefuran 8% WG @ 625 g in 500 litre of water/ ha or Emamectin Benzoate 1.1% + Diafenthiuron 30% SC @ 1000 ml in 500 litre of water/ha or Fluxametamide 3.8% w/w + Pyridaben 9.5% w/w SC @ 1000 ml in 500 litre of water/ha	5	0.00
2	Bacterial wilt	Low	Collect and destroy infected plants immediately	12	91.67
		Medium	Grow resistant varieties and disease-free field. A soil pH between 5.5 and 7.0, good soil drainage and raised beds help to reduce disease pressure. Crop rotation with non-solanaceous hosts. Green manuring with Brassica sp (biofumigation). Clean field and effected parts are to be collected and burnt. Soil solarization with a transparent polyethylene sheet (125 µm thick) for 8-10 weeks during March-June in nurseries. Flooding the field for 1-3 weeks before planting will reduce bacterial wilt. Growing marigold (Tagetes spp.)	23	30.43
		High	Grow resistant varieties and disease-free field. A soil pH between 5.5 and 7.0, good soil drainage and raised beds help to reduce disease pressure. Crop rotation with non-solanaceous hosts. Green manuring with Brassica sp (biofumigation). Clean field and effected parts are to be collected and burnt. Soil solarization with a transparent polyethylene sheet (125 µm thick) for 8-10 weeks during March-June in nurseries. Flooding the field for 1-3 weeks before planting will reduce bacterial wilt. Growing marigold (Tagetes spp.)	03	33.33
Overall pest management advisory services followed by farmers				97	43.30

pheromone traps or releasing natural enemies, while KVK and Department teams can prepare critical inputs ahead of anticipated demand peaks.

The differences observed across crops suggest further targeting opportunities (Khanganbi & Priya, 2024). In paddy, where water management is frequently recommended, advisories could include micro-how-to and photo prompts within the app to clarify instructions. In brinjal, sanitation discipline and rapid rouging are crucial: short, pictorial checklists and 24–48 hours action nudges after detection could help maintain the high compliance noted at low severity. Two limitations should be acknowledged. The cross-sectional, purposive design provided an initial assessment of a newly launched public digital system; thus, causality cannot be established. Additionally, self-reported adherence may be subject to recall or social desirability bias. The evidence indicated that NPSS served as an effective signal generator, while successful implementation depended on simplifying, lowering the cost of, and clarifying high-severity advice-along with aligning digital messages with the rhythms and constraints of smallholder decision-making (Samanta et al., 2020).

CONCLUSION

The study revealed that NPSS advisories effectively reached farmers, but only led to on-farm action approximately 50 per cent of the time. Crop-specific uptake for paddy and brinjal remained below 50 per cent. Adherence generally declined with increasing severity of issues; for instance, compliance for BPH dropped from 47.73 per cent at low severity to 32.47 per cent at high severity, while adherence for YSB fell to 10 per cent at high severity. To enhance compliance, it is essential to provide phased, cost-effective options, localisation of recommendations to match locally available inputs and pack sizes, timely nudges through apps and SMS/voice messages, and pre-positioned inputs in collaboration with KVK/ Department partners. Recommend integration with input supply chains, strengthening local bio-agent availability, and analysing socio-economic predictors of compliance in future studies. Lastly, the NPSS serves as an effective signal; implementation improves when advice is simpler, more affordable, and clearer within the context of farmers' actual decision-making processes.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the respondents during the course of the research.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The authors declare that during the preparation of this work, thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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