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# "Combating Counterfeit Pesticides in India through the QR Trace Shield Model: A Technological Intervention"

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*Abstract* – **The rise in fake and duplicate pesticide products in India has become a serious problem, affecting farmers' livelihoods, crop health, and overall agricultural output. Many farmers unknowingly purchase these counterfeit pesticides, which often look like genuine brands but contain harmful or ineffective substances. This leads to crop damage, soil degradation, financial losses, and health issues for both farmers and consumers. Current laws and systems are not strong enough to track and prevent the sale of such products, mainly because of limited technology use, low farmer awareness, and lack of real-time monitoring. This research proposes a practical and technology-based solution called the QR Trace Shield Model, designed to prevent duplication of pesticide products. In this model, each pesticide container will have a secure QR code printed at the manufacturing stage. This code contains important details like batch number, manufacturing date, license, and company information. Farmers and retailers can scan this QR code using a government-approved mobile app to instantly check if the product is genuine. To support this, a centralized system called the Central Pesticide Traceability Portal (CPTP) will store and track the movement of each pesticide batch using block chain technology. The system also includes GPS tracking of licensed sellers, regular inspections by field officers, and surprise audits in markets. Farmers will be trained to use the app and encouraged to report suspicious products. Those who report fake products will receive rewards, discounts, and public recognition. To take quick legal action, a special legal team will handle complaints using digital evidence collected from QR scans and location data. Overall, the QR Trace Shield Model can help build trust in the pesticide market, empower farmers to make safer choices, and reduce the spread of counterfeit products. It also supports the government's push for digital agriculture and could serve as a model for other countries facing similar problems in the farming sector.**

*Keywords* – **Counterfeit Pesticides, QR Code Authentication, Traceability System, Digital Agriculture, Block chain Technology, Pesticide Supply Chain, Agricultural Inputs Technology Intervention, Pesticide Regulation in India.**

## I. Introduction

Agriculture remains a vital pillar of the Indian economy, supporting millions of livelihoods and contributing significantly to national food security. To maintain crop health and productivity, the use of pesticides has become a widespread practice among Indian farmers. Unfortunately, a growing concern has emerged around the circulation of counterfeit pesticide products in the market. These fake or duplicate pesticides often look identical to authentic ones but fail to deliver the expected results due to the absence or dilution of key active ingredients. This not only results in crop damage and financial losses for farmers but also poses threats to soil fertility, human health, and the environment. Recent estimates suggest that a considerable portion ranging between 25% to 30% of pesticides available in the Indian market may be spurious or unregistered. The problem is especially pronounced in rural and remote regions, where access to information and regulatory oversight is limited. Farmers in these areas are more vulnerable to purchasing substandard products due to the lack of verification tools and awareness. Despite the presence of regulatory mechanisms under the Insecticides Act, 1968 and institutions such as the Central Insecticides Board and Registration Committee (CIBRC), the current systems are unable to effectively curb the widespread sale of fake agrochemical products.

This research focuses on addressing the issue of pesticide duplication by introducing a digitally-enabled traceability framework referred to as the QR Trace Shield Model. This model proposes the integration of a unique, tamper-proof QR code on every pesticide container at the time of production. Each code would contain encrypted data, including product information, batch details, licensing numbers, and official certifications. By scanning the code through an authorized mobile application, farmers, retailers, and inspectors would be able to instantly verify the product's authenticity.

The proposed model is further supported by a centralized traceability portal, known as the Central Pesticide Traceability Portal (CPTP). This digital infrastructure would allow the government and related stakeholders to track every unit of pesticide from manufacturing to sale. Technologies like blockchain would ensure the transparency and security of the data. Additionally, geo-tagging of dealers, mobile inspection teams, legal enforcement mechanisms, and incentive-based farmer participation form an integral part of the system. The ultimate goal of this research is to build a scalable, transparent, and farmer-friendly solution that significantly reduces the sale and use of counterfeit pesticides. By promoting real-time product verification, digital monitoring, and coordinated enforcement, the QR Trace Shield Model has the potential to restore confidence in the agricultural input system and enhance overall farming outcomes.

## II. Research Methodology

### 2.1. *Type of Research*

The present study employs a descriptive and exploratory approach, focusing on the application of a digital solution the QR Trace Shield Model or addressing the issue of counterfeit pesticides in India. This methodology helps in understanding both the framework and its implications in a real-world agricultural setting.

### 2.2. *Nature and Source of Data*

This research is qualitative and relies solely on secondary data. Information has been gathered from:

- Official government records (Ministry of Agriculture, CIBRC reports).
- Industry publications (white papers from companies like UPL, Bayer).
- Peer-reviewed journal articles.
- Technology-based documentation on block chain, QR authentication, and traceability.
- Verified news outlets covering field operations, legal actions, and farmer feedback.

### 2.3. *Method of Data Collection*

Secondary data was collected through online portals, databases, journals, government websites, industry reports, and digital agriculture case studies. Emphasis was placed on collecting up-to-date, credible, and relevant information to support the model's structure and outcomes.

### 2.4. *Tools for Analysis*

The data and information collected were analyzed using the following techniques:

- Thematic Analysis: Core ideas such as QR code integration, blockchain traceability, and legal enforcement were identified and discussed.
- Process Flow Charting: A logical representation of the QR model was developed to show the flow of activities from manufacturing to farmer-level usage.
- Comparative Review: The proposed system was compared with traditional counterfeiting methods to highlight improvements.
- Tabular Outcomes: Predicted impacts were structured into tables to make the findings clear and practical.

### 2.5. *Area and Focus of the Study*

The research focuses on the Indian agricultural input sector, specifically the pesticide distribution and supply chain. It includes various stakeholders-manufacturers, dealers, retailers, farmers, and regulatory bodies-who are influenced by or involved in the prevention of counterfeit products.

### 2.6. *Technologies and Concepts Studied*

The data and information collected were analyzed using the following techniques:

- Thematic Analysis: Core ideas such as QR code integration, block chain traceability, and legal enforcement were identified and discussed.
- Process Flow Charting: A logical representation of the QR model was developed to show the flow of activities from manufacturing to farmer-level usage.
- Comparative Review: The proposed system was compared with traditional anti-counterfeiting methods to highlight improvements.
- Tabular Outcomes: Predicted impacts were structured into tables to make the findings clear and practical.

## IV. Results and Discussion

The QR Trace Shield Model introduces an innovative and multi-dimensional strategy to tackle the growing issue of counterfeit pesticides in India. By leveraging digital technologies alongside strong regulatory oversight, this model builds a transparent and accountable pesticide distribution system-from production all the way to on-farm use.

### 4.1. *Smart QR Code Authentication System*

Each pesticide pack carries a unique, encrypted QR code printed at the time of manufacturing. This code includes essential product information like the license number, batch ID, date of manufacturing and expiry, CIBRC registration, and price. Farmers and retailers can verify the product instantly by scanning the code through a government-authorized app such as Krishi Rakshak. If the code is invalid or has been duplicated, the system flags it immediately.

### 4.2. *Central Pesticide Traceability Portal (CPTP)*

This platform records every pesticide batch from the point of manufacturing to final delivery. By adopting blockchain technology, the data is stored securely and cannot be altered. Every actor in the supply chain is requ-

-ired to register. In case of irregularities, the system sends out automated alerts.

4.3. *Geo-Tagging of Retailers and Dealers*

Each authorized seller is linked to a GPS location using a mobile app. This allows real-time tracking of where and how pesticide stocks are moving. This step reduces the chances of counterfeit distribution in rural regions.

4.4. *Mobile Inspection Teams*

Teams are equipped with QR code scanners, chemical testing kits, and tablets connected to the CPTP. Based on alerts or complaints, they conduct surprise checks and take strict actions in case of non-compliance.

4.5. *Farmer Awareness and Incentive Program*

Farmers are trained in regional languages through KVKs and local gatherings. Monetary incentives and rewards are offered to encourage reporting of counterfeit pesticides.

4.6. *Public-Private Surveillance Network*

A collaborative effort among government bodies, agrochemical companies, and NGOs to share information on counterfeit cases and market surveillance techniques.

4.7. *Fast-Track Legal Action Cell*

Dedicated legal unit to handle counterfeit-related cases using digital proof such as QR scan records and transaction logs.

Table 1. Functional Components and Outcomes.

| Component | Purpose | Result |
|---|---|---|
| Smart QR Code Authentication | Unique QR code verification via mobile app | Prevents use of duplicate or expired pesticide products |
| Central Pesticide Traceability Portal (CPTP) | Blockchain-based tracking from factory to farm | Ensures transparency and traceability in pesticide distribution |
| Geo-Tagging of Dealers | Linking each seller with GPS coordinates | Identifies unauthorized or unlicensed sales outlets |
| Surprise Inspections | District-level teams using mobile tools and scan devices | Immediate detection of fake pesticides; enables legal action |
| Farmer Incentive Program | Rewards for reporting counterfeit products | Increases farmer vigilance and participation |
| Public-Private Collaboration | Joint surveillance and information-sharing among stakeholders | Strengthens market-level monitoring and response |
| Legal Action Cell | Dedicated legal unit using digital evidence | Fast case resolution; discourages repeat offenses |

Table 2. Implementation of budget for QR Trace Shield Model.

| Component | Details | Estimated Cost (INR) |
|---|---|---|
| QR Code Generation & Printing | Basic QR code labels with serialization | Rs.2,00,000 |

| Component | Details | Estimated Cost (INR) |
|---|---|---|
| Mobile App (Basic Version) | Lightweight Android-only app with scan & verify features | Rs.3,00,000 |
| Centralized Tracking (Simplified Web Portal) | Non-blockchain, SQL-based traceability portal | Rs.4,00,000 |
| GPS Tagging of Retailers | Use of Google Maps API integration | Rs.1,00,000 |
| Server Hosting (Shared Cloud) | Shared hosting, basic security layers | Rs.1,00,000 |
| Mobile Inspection Setup | QR scanners integrated in smartphones (for 5 teams) | Rs.3,00,000 |
| Farmer Awareness & Training | Basic flyers, local language sessions via Krishi Vigyan Kendra (KVK) | Rs.1,00,000 |
| Incentive & Reward System | Cash rewards/public appreciation for genuine reports | Rs.1,00,000 |
| Legal Support Setup | Local legal volunteer or part-time digital complaint handling | Rs.1,00,000 |
| Administration & Monitoring | Single project coordinator, part-time tech support | Rs.3,00,000 |

Total Low-Cost Estimated Expenditure: Rs.20, 00,000 (20 Lakhs INR).

The low-cost budget of Rs.20 lakhs for the QR Trace Shield Model presents a practical and scalable solution for pilot-level implementation in a single district. It focuses on essential components like QR code labeling, a basic mobile app, and a simple traceability portal without expensive blockchain systems. Existing infrastructure such as KVKs is utilized for training, and smartphones replace costly hardware for inspections. A small reward system encourages farmer participation, while minimal staffing ensures lower administrative expenses. This budget-friendly model demonstrates how technology-driven pesticide authentication can be launched effectively on a limited scale and later expanded.

Table 3. Key Benefits of QR Trace Shield Model.

| Benefit | Explanation |
|---|---|
| Real-Time Monitoring | Tracks pesticide movement instantly from source to usage |
| Reduced Counterfeiting | Eliminates unverified and fake products from entering the market |
| Farmer Empowerment | Enables independent product verification using mobile applications |
| Restores Trust | Improves confidence in pesticide quality and government regulation |
| Push Toward Digital Ag | Encourages use of digital tools in agriculture and improves rural tech adoption |

Overall, the QR Trace Shield Model demonstrates that technology, when properly integrated with regulation and local-level awareness, can play a critical role in solving the issue of counterfeit pesticides. By combining authentication, traceability, geo-tracking, enforcement, and farmer engagement, the model builds a secure, digital, and farmer-friendly solution to an issue that has long plagued Indian agriculture.

## V. Conclusion

The QR Trace Shield Model presents a forward-thinking solution to the persistent issue of counterfeit pesticides in India. By integrating secure QR code authentication with digital traceability systems, the model enhances transparency across the pesticide supply chain. It empowers farmers to independently verify product authenticity using simple mobile tools, thereby reducing reliance on informal sources. The use of technologies such as GPS tracking and centralized monitoring also helps in identifying and restricting unauthorized sellers. Additionally, farmer awareness campaigns and incentive-based reporting create a participatory environment for early detection of fake products. Legal enforcement backed by digital evidence ensures swift action against defaulters. The low-cost structure makes it ideal for phased implementation, starting at the district level and expanding nationally. This model not only curbs pesticide duplication but also supports India's broader goals of promoting digital agriculture and improving farmer welfare. Its adaptable design may also serve as a reference for other nations facing similar agricultural.

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