

Commercial Adoption of AI-Based Cotton Disease Diagnostics in Vidarbha

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Abstract:

Cotton cultivation is an important source of agricultural income in the Vidarbha region of Maharashtra, yet disease outbreaks can threaten yield and increase crop-protection costs. Deep-learning computer-vision models, including MobileNetV2 and ResNet-50, offer promising ways to identify foliar symptoms from leaf images. However, technical performance alone does not ensure adoption by smallholder farmers. This paper examines the commercial viability and go-to-market options for AI-powered cotton disease diagnostic tools from an agri-business perspective. It uses the Technology Acceptance Model (TAM), supplemented by the Unified Theory of Acceptance and Use of Technology (UTAUT), to frame adoption around perceived usefulness, ease of use, price sensitivity, digital access, and trust in local agricultural advisers. A per-acre cost-benefit illustration compares conventional scouting and spraying with a proposed AI-supported targeted-intervention model. The supplied illustrative table estimates total disease-management and production-loss outlays of INR 15,500 under conventional management and INR 6,200 under the proposed model, implying a difference of INR 9,300 per acre. These figures are scenario estimates and require validation against field records and local agronomic costs before being treated as measured savings. The paper also compares direct-to-consumer subscriptions with business-to-business-to-consumer partnerships involving Krishi Seva Kendras, farmer producer organizations, and agricultural input companies. It proposes low-bandwidth vernacular interfaces, seasonal pricing, field demonstrations, and institutional validation as ways to reduce adoption barriers. The analysis concludes that scalable commercialization depends on combining reliable diagnostics with farmer trust, affordable access, and viable rural distribution partnerships.

Keywords — Agri-Business, Technology Acceptance Model (TAM), Go-to-Market Strategy, Cotton Agronomy, Precision Agriculture, Vidarbha

1. INTRODUCTION

Cotton (*Gossypium hirsutum*) is an important cash crop in the Vidarbha agricultural belt of Maharashtra, supporting rural household incomes and textile value chains. Cotton growers face variable farm returns due to weather conditions, market-price fluctuations, and crop disease outbreaks. Foliar diseases, including bacterial

blight, target spot, and cotton leaf curl disease, can affect plant health and yield. The extent of loss varies with disease pressure, crop stage, management practices, and environmental conditions; therefore, loss estimates should be supported by region-specific agronomic evidence.

In conventional practice, diagnosis may rely on farmers' visual assessment or advice from local

agricultural input dealers. Symptoms from different diseases can overlap, and uncertain diagnosis may lead to unnecessary or poorly targeted chemical applications. This can increase input costs and may have environmental and resistance-management consequences. Deep convolutional neural networks (CNNs) can classify plant images and have potential to support early crop-health screening through smartphones. Nevertheless, model performance in a dataset or laboratory does not automatically translate into reliable field performance or farmer adoption. Real-world uptake also depends on affordability, digital literacy, smartphone capabilities, connectivity, trust, and the availability of useful follow-up advice.

This paper examines commercialization dynamics for AI-supported cotton disease diagnostics from an agri-business perspective. It considers an illustrative cost-benefit model, adoption barriers, pricing, and distribution channels relevant to the Vidarbha region. The paper is a strategic analysis based on the supplied scenario and literature; the economic estimates should be validated through field trials before being presented as demonstrated outcomes.

2. THEORETICAL FOUNDATION: TECHNOLOGY ACCEPTANCE IN AGRICULTURE

The study uses the Technology Acceptance Model (TAM) developed by Davis (1989), supplemented by the Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh et al. (2003). TAM explains technology acceptance through perceived usefulness and perceived ease of use.

2.1 Perceived Usefulness

Perceived usefulness refers to the extent to which a farmer believes that a diagnostic tool can improve crop-management decisions, reduce unnecessary expenditure, or support timely action against disease. Farmers are more likely to consider adoption if the tool provides clear, locally relevant advice and demonstrable value.

2.2 Perceived Ease of Use

Perceived ease of use concerns how easily farmers can operate the tool. Simple navigation, voice support in Marathi and Hindi, readable instructions, and the ability to function with intermittent connectivity may reduce barriers for users with varying levels of digital literacy.

2.3 Financial Risk and Social Influence

Smallholder farmers often make seasonal spending decisions under financial constraints, so subscription fees and uncertain returns may limit willingness to pay. UTAUT also emphasizes social influence and facilitating conditions. In rural agriculture, peer farmers, extension officers, farmer producer organizations, and local input retailers may affect trust and adoption. The incentives of distribution partners should be aligned with accurate, responsible recommendations.

3. ECONOMIC COST-BENEFIT ANALYSIS: PREVENTIVE SCOUTING VS. CHEMICAL OVERUSE

To illustrate the possible value proposition, the supplied scenario compares conventional disease management with a proposed AI-supported targeted-intervention approach. The figures below are reproduced from the provided draft; they are not independently verified observations. The table should be treated as an illustrative model until the underlying assumptions, local prices, disease incidence, and yield-loss estimates are documented.

TABLE I. ILLUSTRATIVE PER-ACRE SEASONAL ECONOMIC COMPARISON FOR COTTON CULTIVATION IN VIDARBHA

Expenditure / yield metric	Conventional management (INR)	AI precision diagnostic scenario (INR)
Average scouting and diagnosis labour cost	1,200	200
Foliar chemical spray costs	5,800 (4–5 blanket sprays)	3,200 (2 targeted sprays)
Chemical application labour / equipment	2,000	1,000
Preventable disease-related crop loss estimate	6,500 (approx. 25% loss)	1,800 (controlled early infection)
Total estimated outlay and disease-related loss	15,500	6,200
Difference versus conventional scenario	Baseline	9,300 lower (illustrative)

Using the totals shown in Table I, the difference between the two scenarios is INR 9,300 per acre (INR 15,500 minus INR 6,200). This is a

modelled difference, not proof that every farmer will save this amount. A robust economic evaluation should state whether diagnostic-tool fees, training, device costs, service-provider commissions, and any additional treatment costs are included. It should also test outcomes across low, moderate, and high disease-pressure seasons.

4. GO-TO-MARKET (GTM) AND DISTRIBUTION STRATEGY

Direct-to-consumer agricultural apps may face high customer acquisition costs and seasonal engagement, because farmers' need for disease diagnosis changes over the crop cycle. A multi-channel approach may improve reach by embedding the service within existing agricultural advisory and input networks. Each channel should be tested for farmer benefit, partner incentives, operating cost, and diagnostic quality.

4.1 The 4Ps Marketing Mix for Agri-Diagnostic Tools

Product: The proposed platform would use a lightweight interface with Marathi and Hindi voice support and, where technically feasible, offline image inference using an optimized model such as MobileNetV2. It should provide understandable results, confidence or uncertainty indicators, and safe next steps. Chemical dosage recommendations should be evidence-based, label-compliant, and reviewed by qualified agronomy experts; the tool should direct uncertain or severe cases to human specialists.

Price: A freemium option could allow a limited number of free diagnoses per growing season, with a seasonal pass proposed at INR 99–199. These are proposed price points rather than validated willingness-to-pay results. Alternatives include bundling access with advisory services or institutional licenses. Pricing tests should measure adoption, repeat use, affordability, and service sustainability.

Place: Possible distribution partners include Krishi Seva Kendras, farmer producer organizations (FPOs), cooperatives, and agricultural input companies. Retailers could offer a diagnostic service using a tablet or smartphone, while FPOs could purchase group access for

members. Corporate partnerships may provide wider reach but should include safeguards to prevent product recommendations from being biased by commercial incentives.

Promotion: Farmer field demonstrations, village-level meetings, agricultural extension events, community radio, and WhatsApp advisory groups could help build awareness. Demonstrations should compare the tool's outputs with qualified agronomic assessments and transparently explain the system's limitations.

TABLE II. STRATEGIC COMPARISON OF COMMERCIALIZATION CHANNELS

Channel model	Target customer / partner	Revenue mechanism	Potential bottlenecks	Indicative viability
Direct B2C mobile app	Individual farmer	In-app or seasonal subscription	Low willingness to pay; seasonal churn; acquisition costs	Requires validation
B2B2C via local input retailers	Krishi Seva Kendra retailers and visiting farmers	Commission per scan or annual service licence	Partner incentives; trust; service consistency	Potentially promising
B2B enterprise partnerships	Seed/agrochemical firms, FPOs, institutions	Annual software licence or service contract	Long sales cycles; procurement and contract delays	Potentially scalable

The channel comparison is a strategic assessment, not the result of a measured profitability study. The viability of each model depends on partner acquisition costs, service usage, renewal rates, farmer outcomes, and safeguards for independent diagnosis.

5. MITIGATING STRUCTURAL ADOPTION BARRIERS

5.1 Aligning Dealer Incentives

Local input retailers may be influential advisers and potential service partners. If diagnostic recommendations reduce unnecessary chemical sales, some retailers may perceive the tool as a threat to revenue. A partnership model could compensate retailers for legitimate diagnostic services, advisory support, or fulfilment of appropriate products. However, compensation must not encourage unnecessary spraying or steer diagnoses toward particular brands. Recommendation rules should be transparent and based on approved agronomic guidance.

5.2 Addressing Smartphone and Connectivity Constraints

Rural field conditions may include intermittent network coverage and entry-level smartphones with variable camera quality. Offline capability, compressed models, clear image-capture instructions, lighting guidance, and device testing can improve usability. Performance should be evaluated using cotton leaf images captured in real fields, across disease stages, lighting conditions, and device types. The system should communicate uncertainty and avoid presenting image classification as a substitute for professional diagnosis when results are inconclusive.

5.3 Building Institutional Credibility

Collaboration with agricultural universities, extension services, and qualified plant pathologists can support field validation and farmer training. Regional institutions such as Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, could be approached for independent evaluation; no partnership should be implied unless formally established. Validation should examine diagnostic accuracy under field conditions, false-positive and false-negative rates, usability, and whether recommendations improve outcomes without increasing unnecessary chemical use.

5.4 Evaluating Commercial Performance

A pilot should track both business and farmer-outcome indicators. Business measures may include cost per active farmer, conversion to paid use, partner retention, renewal, and service margin. Farmer-outcome measures may include time to diagnosis, verified disease classification, spray decisions, input expenditure, crop outcomes, and user satisfaction. Baseline and follow-up measurements, transparent assumptions, and independent review would make claims of economic benefit more credible.

6. CONCLUSION

AI-powered crop diagnostics may support more timely and targeted cotton disease management, but commercial success depends on more than model accuracy. For cotton farmers in Vidarbha, an effective service must be affordable, usable on

common devices, understandable in local languages, and supported by trusted agricultural advice. A B2B2C approach involving Krishi Seva Kendras, FPOs, and institutional partners may offer a route to wider access, provided partner incentives preserve the independence and safety of recommendations.

The supplied cost-benefit illustration shows a difference of INR 9,300 per acre between its two scenarios, but this estimate is not independently validated. Future work should conduct field trials, assess willingness to pay, compare commercialization channels, and document both economic outcomes and diagnostic performance. A combination of validated technology, responsible advisory practices, and evidence-based distribution partnerships offers the strongest basis for sustainable agri-tech commercialization.

REFERENCES

- [1] Aker, J. C. (2011). Dial “A” for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics*, 42(6), 631–647.
- [2] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340.
- [3] Feder, G., Just, R. E., & Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change*, 33(2), 255–298.
- [4] Mittal, S., & Mehar, M. (2016). Socio-economic factors affecting adoption of modern information and communication technology by farmers in India. *Information Technologies & International Development*, 12(4), 17–28.
- [5] National Bank for Agriculture and Rural Development. (2023). State Focus Paper: Maharashtra Agronomic Infrastructure and Credit Potential. NABARD.
- [6] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425–478.