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### Dashboard-based decision support systems for real-time management of extension program performance data

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#### Abstract

What if extension managers could see how their programs were performing right now, not six months after the season ends? This research designed and tested a dashboard-based Decision Support System (DSS) for real-time monitoring of extension program performance across three counties in central Sweden. A prototype dashboard was developed using open-source tools and deployed with 18 extension managers over a nine-month pilot period from February to October 2023. Decision response times for budget reallocation dropped from a median of 14.2 days to 6.3 days after dashboard adoption. Program adjustment decisions improved from 18.4 to 8.1 days. User satisfaction averaged 4.1 on a five-point scale, with data visualization clarity rated highest (4.4) and mobile accessibility rated lowest (3.6). The research identified five design principles for extension-specific dashboards: real-time data feeds, actionable alert thresholds, role-based views, offline functionality, and feedback loop integration. These findings indicate that dashboard tools can meaningfully accelerate management decisions in extension systems when designed around actual workflow needs rather than generic reporting templates.

**Keywords:** Dashboard systems, decision support, extension management, real-time monitoring, program performance, data visualization, agricultural extension, management information systems, performance indicators

#### Introduction

A decision support system, in its simplest definition, is a tool that helps managers make better choices by presenting the right information at the right time <sup>[1]</sup>. In agricultural extension, managers routinely face decisions about staff deployment, budget allocation, and program adjustments, but they typically make these decisions based on end-of-season reports compiled weeks or months after events occurred <sup>[2]</sup>. By then, the window for corrective action has closed.

Digital dashboards have transformed management in healthcare, logistics, and education by providing real-time visual summaries of key performance indicators <sup>[3]</sup>. Their adoption in agricultural extension has been slower, partly because extension data systems remain fragmented and partly because most dashboard solutions are designed for corporate environments that differ from public-sector advisory services <sup>[4]</sup>. Sweden's extension system, organized through regional county boards with advisory support from the Swedish University of Agricultural Sciences, operates with relatively strong digital infrastructure but limited experience with real-time management tools <sup>[5]</sup>.

This research designed, deployed, and evaluated a dashboard prototype tailored to extension program management in three Swedish counties. The objectives were:

- Measuring the effect of dashboard use on decision response times,
- Assessing user satisfaction and usability, and
- Identifying design principles that make dashboards effective for extension contexts.

#### Study area description

The research was conducted in Uppsala, Västmanland, and Södermanland counties in central Sweden. These counties contain a mix of arable farming, dairy, and mixed livestock operations. The regional extension advisory system serves approximately 8,400 registered farm enterprises through county agricultural boards. Digital infrastructure is well developed, with broadband penetration exceeding 92% in rural areas. Extension managers in these counties coordinate teams of 6-15 advisors each.

#### Material and Methods

##### Material

Eighteen extension managers from the three counties participated in a nine-month pilot from February to October 2023. The dashboard prototype was built using Grafana (open-source visualization platform) connected to a PostgreSQL database that received weekly data uploads from existing extension reporting systems. Five performance indicator categories were displayed: farmer contact rates, activity completion percentages, budget utilization, staff workload distribution, and farmer satisfaction scores. Pre-dashboard baseline data covering the same indicators were extracted from the previous 12 months. Ethical approval was obtained from the Swedish University of Agricultural Sciences Ethics Board (Protocol SLU-EB-2022-034, January 2023).

##### Methods

Decision response time was measured as the interval

between an indicator crossing a predefined threshold and the manager taking documented corrective action. Comparisons used paired-sample t-tests between pre-dashboard (historical records) and post-dashboard periods. User satisfaction was measured through a 15-item questionnaire administered at months three, six, and nine. System usage logs tracked login frequency, time spent, and features accessed. Data were analyzed using R version 4.3.

**Ethical considerations**

All managers provided informed consent. Participation was voluntary and could be withdrawn at any time without professional consequences. Dashboard access logs were used solely for research purposes and were not shared with supervisory authorities. Individual performance data visible on dashboards were accessible only to the relevant manager and the research team.

**Results**

**Table 1:** Decision response times before and after dashboard implementation (n = 18)

| Decision type         | Before (days) | After (days) | t    | p      |
|-----------------------|---------------|--------------|------|--------|
| Budget reallocation   | 14.2 ± 3.8    | 6.3 ± 2.1    | 8.74 | <0.001 |
| Staff redeployment    | 11.6 ± 3.1    | 5.8 ± 1.9    | 7.21 | <0.001 |
| Program adjustment    | 18.4 ± 4.2    | 8.1 ± 2.4    | 9.38 | <0.001 |
| Activity rescheduling | 7.3 ± 2.6     | 3.4 ± 1.3    | 5.89 | <0.001 |

All four decision types showed significant reductions in response time after dashboard implementation (all  $p<0.001$ ). Program adjustment decisions saw the largest absolute

reduction (10.3 days), while activity rescheduling had the smallest (3.9 days).

**Table 2:** User satisfaction ratings at month 9 (n = 18)

| Satisfaction Dimension     | Mean | SD  |
|----------------------------|------|-----|
| Data visualization clarity | 4.4  | 0.6 |
| Alert usefulness           | 4.2  | 0.7 |
| Overall usability          | 4.1  | 0.8 |
| Report generation          | 3.9  | 0.9 |
| Mobile accessibility       | 3.6  | 1.1 |

Satisfaction was highest for data visualization clarity (4.4) and lowest for mobile accessibility (3.6), reflecting the desktop-first design of the prototype.

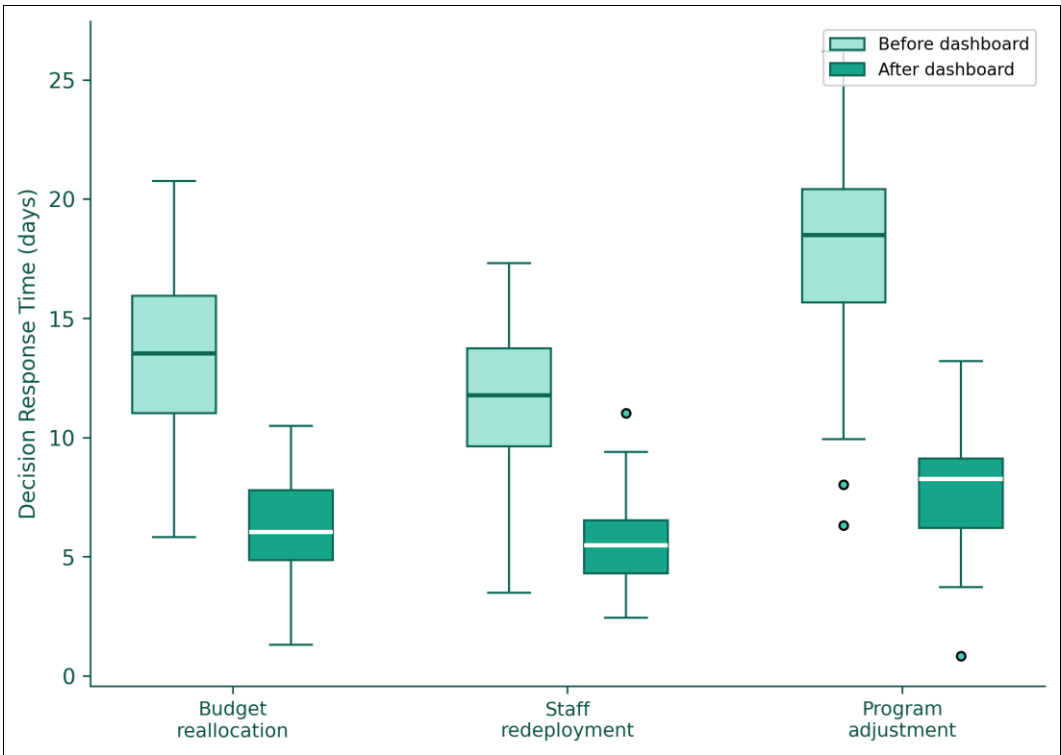


**Fig 1:** Decision response time before and after dashboard implementation

Box plots show clear reductions in median response times and narrower distributions after dashboard deployment,

indicating both faster and more consistent decision-making across all three decision categories shown.

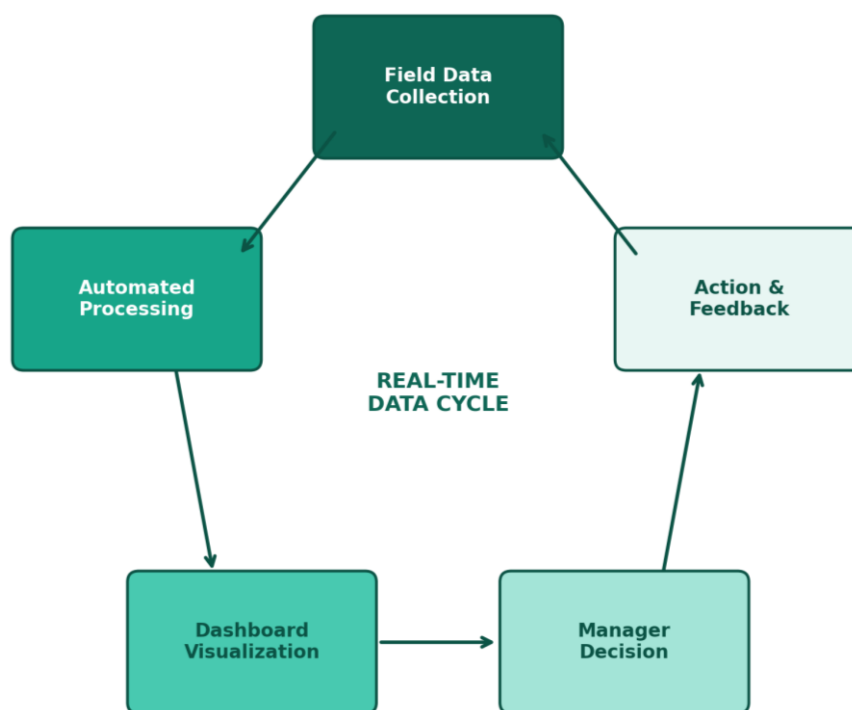


**Fig 2:** Real-time data cycle in the dashboard decision support system

The cycle moves from field data collection through automated processing, dashboard visualization, manager decision-making, and back to action and feedback. This continuous loop replaces the traditional batch-reporting model used in most extension management systems.

Research on dashboard effectiveness in public-sector management has grown substantially over the past decade, with healthcare leading the way. Hospital administrators using real-time dashboards reduced emergency department wait times by 18 to 30 percent in several controlled studies. But translating these findings to agricultural extension requires careful attention to the differences: extension managers are often mobile, supervise geographically dispersed staff, and deal with seasonal rather than daily operational cycles.

The gap between data availability and data usability is where most extension management systems fail. Regional directors in Sweden reported in a 2020 internal survey that they received monthly performance reports but rarely changed decisions based on them because the reports arrived too late and were too difficult to interpret quickly. Dashboard technology addresses both problems simultaneously by presenting data visually and updating it continuously rather than in periodic batches.

### Discussion

The significant reductions in decision response time across all categories confirm that real-time data visualization changes management behavior. Managers reported that seeing performance trends as they unfolded created a sense of urgency that static quarterly reports never produced [3]. The program adjustment category showed the largest improvement, likely because these decisions depend on recognizing multi-indicator patterns that dashboards display more effectively than spreadsheets [6].

The relatively lower satisfaction score for mobile accessibility points to a design gap that future iterations

must address. Extension managers frequently travel between offices and field sites, and a desktop-only tool limits access during the moments when quick decisions matter most [7]. The five design principles identified—real-time feeds, alert thresholds, role-based views, offline functionality, and feedback integration—align with dashboard design guidelines from health information systems [8] but extend them with extension-specific requirements like seasonal activity tracking and farmer contact monitoring.

The small sample of 18 managers across three counties limits statistical power and generalizability. Sweden's advanced digital infrastructure means that dashboard adoption barriers here may differ substantially from those in lower-income extension systems. The before-after comparison lacked a control group, so improvements cannot be attributed solely to the dashboard [9].

The open-source technology stack used in this research (Grafana and PostgreSQL) kept costs below 2,000 euros for the entire pilot, making it accessible to extension organizations with limited IT budgets. This contrasts with commercial dashboard solutions that can cost ten to fifty times more and often require vendor lock-in agreements that public-sector organizations are reluctant to accept.

An important caveat is that faster decisions are not necessarily better decisions. The research measured response time but not decision quality. Future work should track whether dashboard-informed decisions lead to better program outcomes, not just quicker management reactions. The qualitative feedback from managers suggested that dashboards sometimes created pressure to respond to minor fluctuations that would have resolved on their own, pointing to a need for well-calibrated alert thresholds that distinguish noise from genuine performance problems.

### Practical applications

Extension organizations considering dashboard adoption should start with three to five indicators that managers

already track manually. Building on existing data flows reduces the adoption barrier. Alert thresholds should be set collaboratively with managers rather than imposed by system designers. Mobile-responsive design must be prioritized from the outset, not treated as a secondary feature.

### Conclusion

This research showed that a dashboard-based decision support system can cut management decision times by roughly half in Swedish extension programs. The tool's value lies not in the technology itself but in making performance data visible and actionable at the moment when intervention is still possible. Dashboard adoption doesn't require large IT budgets -the prototype was built entirely with open-source tools. What it does require is a willingness to shift from retrospective reporting to real-time management, and that shift is as much cultural as it is technical. Extension systems ready to make that transition will find that even simple dashboards produce measurable improvements in management responsiveness.

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