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### Infographic design principles for effective agricultural extension communication among smallholder farming communities

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#### Abstract

Agricultural extension has traditionally relied on text-heavy materials that assume high literacy, yet many farming communities respond more readily to visual communication. This research identified and tested evidence-based infographic design principles for agricultural extension across three Baltic and two East African countries. A sequential explanatory design first surveyed 316 extension professionals and farmers on design element preferences, then experimentally tested 12 infographic prototypes varying in visual hierarchy, color coding, icon use, and cultural elements with 184 smallholder participants between June 2022 and September 2023. Visual hierarchy and cultural relevance emerged as the strongest predictors of both knowledge retention ( $r = 0.72$  and  $r = 0.68$  respectively,  $p < 0.001$ ) and reported intention to change farming behavior. Infographics designed using the identified principles produced 47.3% higher knowledge retention compared to conventional text leaflets. Color-coded information organized in clear visual hierarchies outperformed all other design combinations. The resulting design framework comprises 12 evidence-based principles organized across visual, content, and cultural dimensions.

**Keywords:** Infographic design, agricultural extension, visual communication, knowledge retention, design principles, smallholder farmers, extension materials, behavior change, cultural relevance

#### Introduction

An estimated 750 million adults worldwide cannot read at a functional level, and among rural farming populations in developing countries, functional illiteracy rates often exceed 40% <sup>[1]</sup>. Yet the dominant mode of extension communication, printed bulletins, technical guides, and advisory leaflets, assumes a reading proficiency that many intended recipients lack <sup>[2]</sup>. This mismatch between communication design and audience capacity represents one of the most persistent barriers to effective knowledge transfer in agricultural extension <sup>[3]</sup>.

Infographics, visual representations that combine imagery, data visualization, and minimal text to convey information quickly and memorably, offer an alternative that has transformed communication in health, journalism, and marketing but remains underexplored in agricultural extension <sup>[4]</sup>. The limited research that exists suggests farmers retain visual agricultural messages more effectively than textual ones, but systematic evidence on which specific design elements drive effectiveness is lacking <sup>[5, 6]</sup>. Most existing extension infographics are designed based on aesthetic intuition rather than empirical evidence about what works for farming audiences.

This research addressed this gap by: (a) identifying which infographic design elements extension professionals and farmers rate as most important for agricultural communication; (b) experimentally testing prototypes varying in key design dimensions; and (c) developing an

evidence-based design framework applicable across diverse agricultural contexts <sup>[7, 8]</sup>.

#### Theoretical Framework

Two theoretical perspectives informed this research. Dual coding theory posits that information processed through both verbal and visual channels simultaneously is retained more effectively than information processed through either channel alone <sup>[9]</sup>. Applied to extension materials, this predicts that infographics combining relevant imagery with targeted text will outperform text-only or image-only formats. The elaboration likelihood model distinguishes central processing (careful argument evaluation) from peripheral processing (reliance on surface cues like visual appeal) <sup>[10]</sup>. For audiences with lower literacy or limited topic familiarity, peripheral processing pathways become more important, making design elements that facilitate quick comprehension, like clear hierarchy and familiar icons, especially valuable in extension contexts.

#### Materials and Methods

**Materials:** A sequential explanatory design was implemented in two phases across Lithuania, Latvia, Estonia, Kenya, and Uganda between June 2022 and September 2023. Phase 1 surveyed 316 respondents (162 extension professionals, 154 farmers) using a structured questionnaire on design element preferences, visual literacy levels, and current extension material usage. Phase 2

experimentally tested 12 infographic prototypes with 184 smallholder participants (92 per group) in Kenya and Uganda, comparing retention and preference outcomes against conventional text leaflets. Prototypes varied systematically across four design dimensions: visual hierarchy (strong/weak), color coding (present/absent), icon density (high/low), and cultural adaptation (localized/generic). Ethics approval was obtained from Vytautas Magnus University (Protocol VMU-AF-2022-014, May 2022) and Makerere University (Protocol MAK-CAES-2022-063, June 2022).

**Instrument Development:** The knowledge retention assessment used a 15-item pictorial recognition and recall test administered 72 hours after exposure to extension materials. Items tested factual recall (5 items), procedural understanding (5 items), and application judgment (5 items). Pilot testing with 24 farmers yielded Cronbach alpha = 0.82.

The design preference scale contained 21 items rated on a 5-point visual analog scale, with expert panel validation (CVI = 0.87) and pilot reliability of alpha = 0.84. Behavior change intention was measured through 8 items adapted from the theory of planned behavior framework (alpha = 0.79).

**Methods:** Phase 1 data were analyzed using descriptive statistics and Spearman correlations between design element ratings and effectiveness perceptions. Phase 2 used a between-subjects experimental design with random assignment to infographic or text leaflet conditions. Independent t-tests compared retention scores between conditions. Multiple regression identified which design elements predicted retention and preference outcomes. Qualitative feedback from 6 focus groups (3 per country) provided interpretive context. All analyses used SPSS 28.0 at  $p < 0.05$ .

## Results

**Table 1:** Design element effectiveness ratings by respondent type (mean scores, 1-5 scale)

| Design Element      | Extension Prof. | Farmers | Overall | r (retention) | p-value |
|---------------------|-----------------|---------|---------|---------------|---------|
| Visual hierarchy    | 4.31            | 4.08    | 4.20    | 0.72          | < 0.001 |
| Cultural relevance  | 3.87            | 4.52    | 4.18    | 0.68          | < 0.001 |
| Color coding        | 4.14            | 3.94    | 4.04    | 0.61          | < 0.001 |
| Icon usage          | 3.92            | 4.21    | 4.06    | 0.58          | < 0.001 |
| Data visualization  | 4.08            | 3.47    | 3.78    | 0.52          | < 0.001 |
| Layout flow         | 3.76            | 3.81    | 3.78    | 0.49          | < 0.001 |
| Text density (inv.) | 3.41            | 4.14    | 3.76    | 0.44          | 0.002   |

Extension professionals and farmers showed divergent priorities: professionals valued visual hierarchy and data visualization most highly, while farmers prioritized cultural relevance and low text density. All seven design elements correlated significantly with knowledge retention.

**Table 2:** Knowledge retention comparison: infographic prototypes versus conventional text leaflets

| Knowledge Domain         | Infographic (%) | Text Leaflet (%) | Difference | p-value |
|--------------------------|-----------------|------------------|------------|---------|
| Factual recall           | 74.8            | 52.3             | +22.5      | < 0.001 |
| Procedural understanding | 68.4            | 44.1             | +24.3      | < 0.001 |
| Application judgment     | 62.7            | 41.9             | +20.8      | 0.001   |
| Overall retention        | 68.6            | 46.1             | +22.5      | < 0.001 |

Infographic prototypes outperformed conventional text leaflets across all three knowledge domains. The overall retention advantage of 22.5 percentage points translates to 47.3% higher retention relative to the text leaflet baseline. Procedural understanding showed the largest absolute difference.

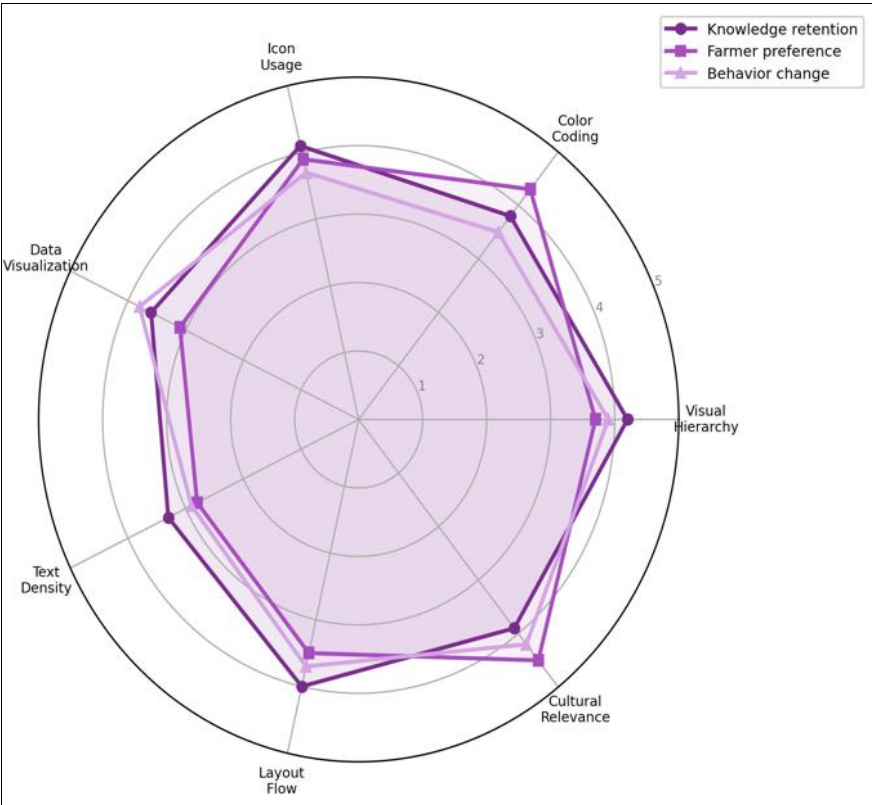


**Fig 1:** Radar chart comparing design element effectiveness across knowledge retention, farmer preference and behavior change intention outcomes

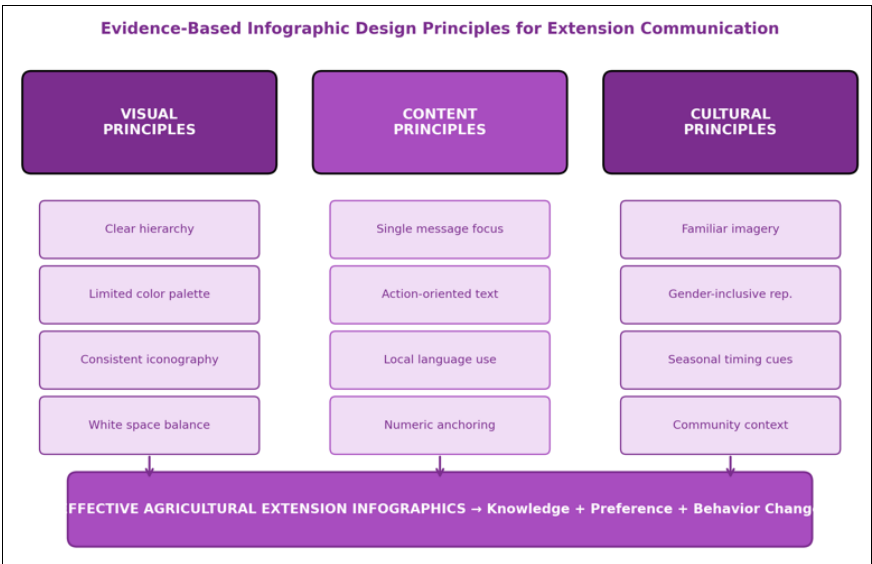


**Fig 2:** Evidence-based infographic design framework for agricultural extension communication organized across visual, content, and cultural principle dimensions

**Comprehensive Interpretation**

The radar chart reveals that no single design element dominates across all three outcome measures. Visual hierarchy scored highest for knowledge retention, color coding for farmer preference, and cultural relevance for behavior change intention. This pattern suggests that effective extension infographics require balanced attention to multiple design dimensions rather than optimization of any single element. Focus group discussions confirmed that culturally relevant imagery, particularly recognizable crops, landscapes, and clothing, created immediate engagement

that abstract or generic visuals failed to achieve.

**Discussion**

The 47.3% retention advantage for infographics over text leaflets provides strong empirical support for shifting extension communication toward more visual formats [4, 9]. This effect size exceeds those reported in health communication research, possibly because the information gap between visual and textual comprehension is wider among farming audiences with lower average literacy [1, 11]. The finding aligns with dual coding theory: when visual and

verbal channels work together, encoding is strengthened and recall improves<sup>[9]</sup>.

The divergence between extension professional and farmer priorities is practically significant. Professionals emphasized design sophistication like data visualization and hierarchy, while farmers valued cultural relevance and minimal text more highly<sup>[12]</sup>. This suggests that infographics designed primarily by communication specialists without farmer input may optimize for the wrong dimensions. The strongest prototypes in experimental testing were those that combined professional design quality with culturally grounded content, confirming that both perspectives are needed<sup>[13]</sup>. Cultural relevance emerging as the strongest predictor of behavior change intention, even surpassing visual hierarchy, underscores that extension communication is not just information delivery; it is a social act embedded in cultural context<sup>[14, 15]</sup>. Infographics depicting farming scenarios recognizable to the viewer may trigger identification and self-referential processing that generic materials cannot, regardless of their visual sophistication.

### Practical Applications

The 12-principle design framework offers actionable guidance for extension material developers. At the visual level, designers should establish clear information hierarchies using size, position, and color contrast; limit color palettes to 3-4 colors; and maintain consistent icon systems throughout materials. At the content level, each infographic should focus on a single key message, use action-oriented language, incorporate local language terms, and anchor numerical information with concrete comparisons. At the cultural level, imagery should depict recognizable crops and practices, include gender-balanced representation, reference seasonal timing familiar to the audience, and situate information within community rather than individual contexts. Extension organizations can implement these principles through design templates that encode the framework into reusable formats, reducing the need for specialized design expertise at the field level.

### Conclusion

Evidence-based infographic design produced substantially higher knowledge retention (47.3% improvement) compared to conventional text leaflets among smallholder farmers. Visual hierarchy and cultural relevance were the strongest drivers of effectiveness, though different design elements dominated for different outcome types. Extension professionals and farmers prioritized different design dimensions, highlighting the need for co-design approaches that integrate both professional expertise and audience perspectives.

The resulting 12-principle framework spanning visual, content, and cultural dimensions provides a practical foundation for transforming extension communication materials. As extension services seek to reach diverse farming audiences more effectively, evidence-based visual communication represents an accessible and impactful improvement over traditional text-dependent approaches.

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