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Dissertation Thesis Abstract

Patterns of Digital Transformation

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Abstract

This thesis explores the effects of digital transformation, shedding light on the path

toward a more digitally integrated society and organizational landscape. It aims to identify recurring challenges and organizational aspects of digital transformation, drawing from practical experience, academic literature, and lessons learned from digital transformation frameworks. These insights are presented in the form of organizational patterns. The most difficult part in digital transformation is not how to bring in the new technology, but how to guide people to understand its potential and learn how to use it. Responding to the thesis that proven digital transformation practices can be collected and operationalized in the form of organizational patterns this work brings the patterns of digital transformation, which address essential aspects of digital transformation, its cultural aspects, and aspects specific to public administration, patterns for bridging the digital gender divide in Afghanistan, as a specific part of digital transformation efforts related the inclusion of women, and evaluation of the patterns, as a survey conducted for the patterns of digital transformation addressing aspects specific to public administration, but also based on observing actual instances of the patterns in practice, which were presented as pattern stories and as examples in pattern descriptions themselves Together, the contributions show that digital transformation is not merely a technological upgrade, but a systemic and cultural shift that requires coordinated patterns of change across people, processes, and institutions. The patterns developed throughout this research provide a framework for policymakers, practitioners, and civil society actors. It emphasizes the importance of iterative, context-aware strategies to build sustainable, inclusive, and resilient digital systems in challenging environments.

Keywords: digital transformation, public administration, digital governance, technology adoption, digital skills, organizational patterns

1. Problem Statement

The idea behind the work reported here can be concisely expressed as the following thesis:
Proven digital transformation practices can be collected and Operationalized in the form of Organizational patterns.

Afghanistan's public-sector digital transformation repeatedly faces similar challenges:

- ✓ low digital literacy
- ✓ weak digital infrastructure
- ✓ resistance to digital change
- ✓ fragmented systems
- ✓ Culture problem
- ✓ poor coordination
- • These challenges and the solutions applied in practice are not documented in a structured, reusable way.
- • As a result, lessons are lost, best practices are not transferred, and projects repeat the same failures.
- • There is no pattern-based framework for guiding digital transformation, because the risk of failure of projects remains high across government organizations.

Research Objective:

Analyze the Problem

Identify key barriers to digital transformation in public organizations.

Develop Solutions

Create reusable and validated organizational patterns to address recurring challenges.

Provide Practical Guidance

Offer actionable insights and evidence-based best practices for effective planning and implementation.

Validate Solutions

Confirm the relevance of the patterns through feedback from public-sector stakeholders.

Research Contributions:

Developed and documented a pattern language for Afghanistan's public-sector digital transformation.

Conducted field research within government ICT projects to identify transformation challenges.

Introduced a story-driven methodology for discovering organizational patterns.

Validated the patterns through a national multi-stakeholder survey.

Provided a practical framework for policymakers and digital transformation practitioners.

Pattern Theory

- Based on Christopher Alexander's pattern language.

- Organizational format adapted from Coplien–Harrison.

- Patterns: structured solutions to recurring problems in a context.

Pattern Structure

- Name

- Context

- Problem

- Forces

- Solution

- Consequences

Pattern Template Example

Name: Digital Literacy for Government Workforce

Context: Many government staff lack basic digital skills, limiting the impact of digital tools.

Problem: Without structured training, employees misuse or avoid digital systems, relying on external consultants and weakening internal capacity.

Force: Digital skills are essential but not developed without targeted training.

Consultants assist with systems but don't build lasting internal skills.

Solution: Introduce mandatory, role-based digital training with ongoing IT support and link progress to performance reviews.

Consequence: Stronger skills boost tool usage, cut consultant reliance, and support lasting transformation.

People-Centered Patterns

• Perform Employee Evaluation

• Digitally Literate Employee

• Promote Employee Confidence

• Digitalization Mindset

Example: Digital Literacy for Government Workforce

• Name: Promote Employee Confidence

• Context: Employees resist digital tools.

• Problem: Fear, lack of support, cultural uncertainty.

• Forces: Employees want to engage with digital tools, but fear making

• mistakes and losing their jobs.

• Solution: Use role models, storytelling, and micro-training.

• Consequence: Improved trust and participation.

Technical and Infrastructure Patterns

• Adopting Updated Technology

• Enabling Infrastructure for Public Sector Growth

• Infrastructure for Cashless Transactions

• Agile Policy Implementation

- Change Management for Digital Adoption

- Cybersecurity for Digital Infrastructures

- Simplify and Standardized Government process

Equity and Inclusion Patterns

- Digital Literacy for Women

- Community-Based Training

- Remote Digital Learning Programs

- Digital Mindset

- Digital Awareness

- Digital Maturity

- Trust Building

Below figure.1 shows an overview of the pattern language these patterns form. The arrows show typical directions in which these patterns are applied, forming meaningful pattern sequences. The sections that follow describe the patterns.
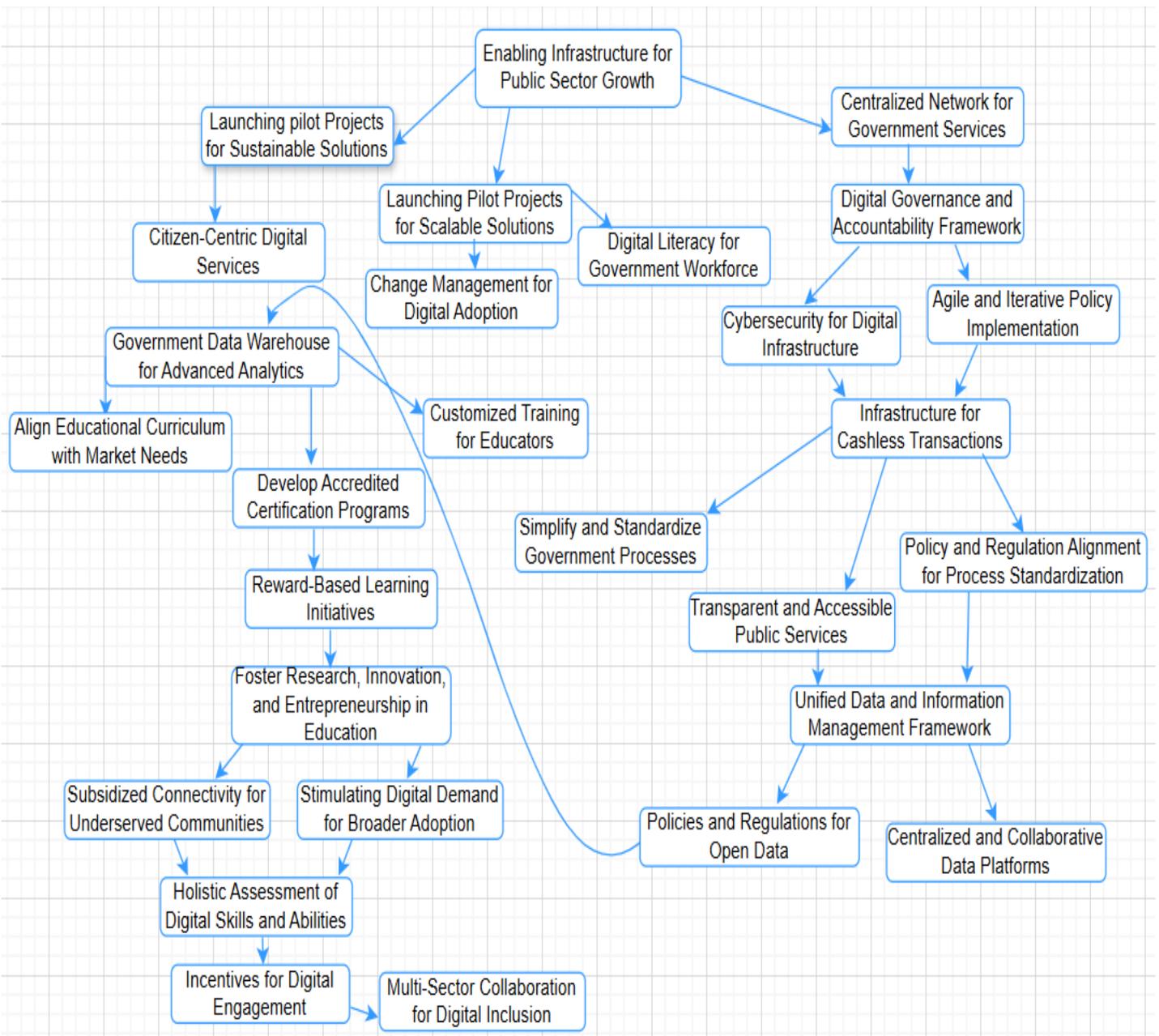
Figure 1: shows an overview of the pattern language

Research Methodology:

This research followed a multi-stage field-based design to systematically study digital transformation efforts in Afghanistan's public sector. The research workflow is depicted in Figure.2.
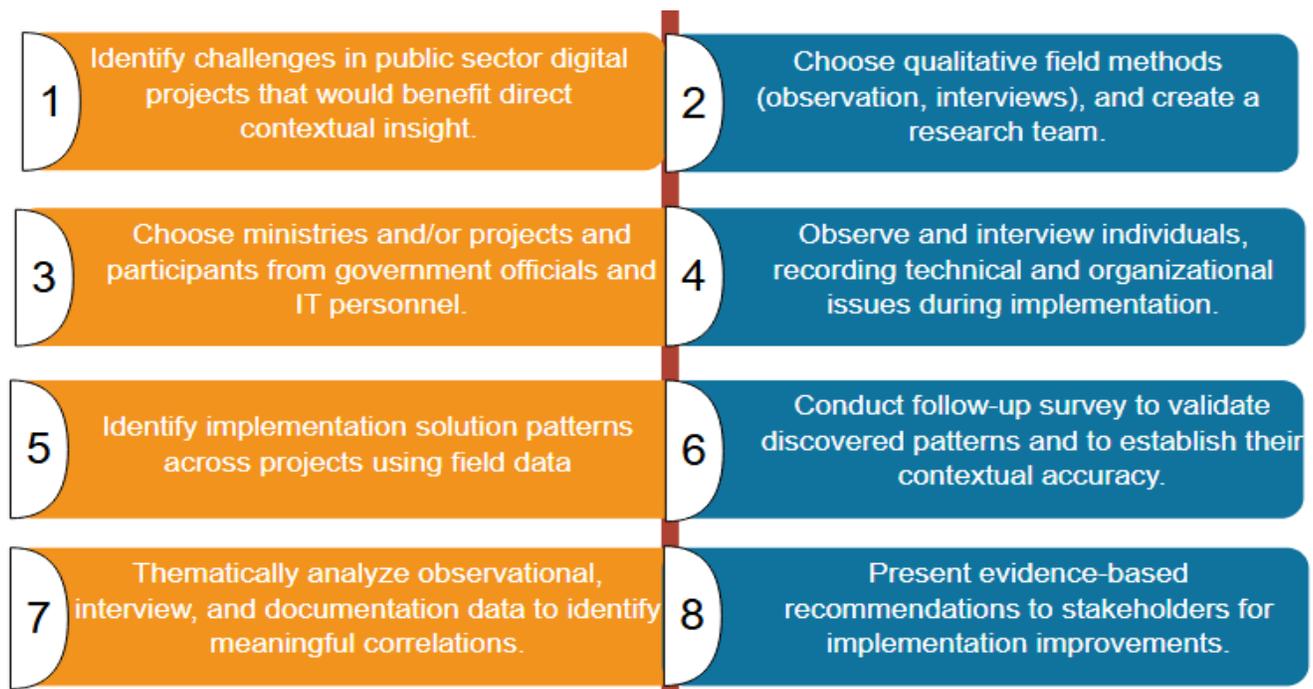

1 Identify challenges in public sector digital projects that would benefit direct contextual insight.	**2** Choose qualitative field methods (observation, interviews), and create a research team.
3 Choose ministries and/or projects and participants from government officials and IT personnel.	**4** Observe and interview individuals, recording technical and organizational issues during implementation.
5 Identify implementation solution patterns across projects using field data	**6** Conduct follow-up survey to validate discovered patterns and to establish their contextual accuracy.
7 Thematically analyze observational, interview, and documentation data to identify meaningful correlations.	**8** Present evidence-based recommendations to stakeholders for implementation improvements.

Figure 2: Research workflow

A. Field Observations and Data Collection:

Between 2019 and 2022, the first author was professionally involved in several major digital transformation initiatives across Afghanistan, gaining firsthand experience in their development and implementation. These included e-Tazkira (national ID), ASAN KHIDMAT (public services), SIGTAS (tax administration), HELMIS (education), and projects within the Ministries of Interior, Higher Education, and Finance. After year 2022, the first author revisited these initiatives through

follow-up field visits, informal discussions with former colleagues, and interviews with stakeholders to reflect on and document recurring challenges and emerging solutions that formed the basis for the patterns presented in this paper.

As a participant-observer in many of these projects, the first author engaged directly with implementation teams, attended project meetings and system demonstrations, and informally interviewed numerous project stakeholders. These unstructured discussions, conducted over multiple visits, offered firsthand insight into the technical, organizational, and cultural challenges encountered during digitalization. Extensive field notes and internal reports were maintained to document emerging issues and solutions.

This study follows qualitative field research principles as outlined by Neuman [44] and Creswell [45], incorporating direct observation, informal interviews, and contextual immersion in natural public sector settings to understand organizational dynamics and digital transformation practices.

B. Pattern Identification and Analysis

The patterns were identified through inductive thematic analysis of the field notes, interview summaries, and project documents. Recurring challenges and their responses were compared across cases, and solutions that reappeared in different contexts were abstracted as transformation patterns. The pattern mining process drew on prior experience of both authors in documenting organizational and technical patterns, with over 15 previous publications in this area.

The patterns presented in this study were shaped through an iterative analysis process grounded in multiple data sources, including field observations, informal interviews, project documentation, government strategies [36], [37], and stakeholder survey responses. The identified patterns were continuously reviewed and refined by the authors in collaboration with two senior colleagues (see acknowledgments). One is a leading author in the pattern community and a direct stakeholder in several of the documented initiatives. The other is a senior public sector practitioner in Afghanistan who provided extensive feedback based on firsthand experience with the studied projects. Their involvement ensured that the patterns reflected practical realities, were clearly articulated, and resonated with the challenges and responses encountered in real-world settings. In line with the Rule of Three often referred to in the pattern community [46], each pattern was derived from at least three distinct instances across different projects. This ensured that the patterns captured recurring solutions applicable beyond isolated cases.

C. Survey Design and Validation

To validate the relevance and applicability of the identified patterns, we conducted a survey using the stratified random sampling method. The five target groups included university lecturers from IT departments, civil servants directly involved in the transformation, government IT staff, recent graduates, and technical staff. The survey involved individuals with firsthand experience or impact in digital transformation initiatives. Importantly, a critical proportion of respondents had direct operational roles in the digitization process, for instance, as civil servants or as observers on inter-

ministerial digital boards. The survey included both structured summative scale questions and open-ended items to obtain validation from both quantitative and qualitative

perspectives. The data was processed and analyzed using Python, including the pandas, seaborn, and matplotlib libraries. Open-ended responses were coded thematically to triangulate with observed patterns. This method combines the approach of participatory observation, informal expert interviews, pattern documentation, and stakeholder validation to ensure that the findings are empirically grounded and methodologically robust. The selection of survey participants followed a random sampling method, concentrating on individuals who were directly or indirectly involved in Afghanistan's major digital transformation projects observed in this study, such as e-Tazkira (national ID), ASAN KHIDMAT (public services), HELMIS (education), and

SIGTAS (tax administration). Participants were selected through institutional contacts, professional networks, and academic affiliations connected to these projects. This approach ensured that respondents possessed relevant knowledge and firsthand experience of the digital transformation processes under investigation. The invitations were distributed electronically via official organizational email channels, academic networks, and professional forums.

All participation was voluntary, and informed consent was obtained from all respondents upon survey completion. This selection strategy ensured a focused yet diverse participant pool, providing insights that accurately represent both the operational and strategic dimensions of Afghanistan's digital transformation efforts. This selection strategy provided a focused yet diverse pool of participants whose insights accurately reflect the operational and strategic dimensions of Afghanistan's digital transformation efforts. A total of 153 correct responses were collected, describing different mixes of participants from government institutions and academia. This diversity delivered valuable, multi-perspective insights into how digital transformation challenges and solutions are perceived across different professional and institutional contexts. The sample size of 153 participants is suitable for an exploratory validation study in applied informatics. It allows for the designation of consistent patterns and relationships between observed challenges and the proposed organizational and technical solutions. However, since participation was voluntary and not restricted to government employees, the findings may not fully reflect all levels of Afghanistan's public administration. The survey sample of 153 participants represents approximately 13% of the total workforce involved in the government projects observed during this study. This ratio delivers a reasonable level of representativeness for validating the identified digital transformation patterns within those specific projects. Although the results do not cover all government institutions, the diversity of respondents ensures a reliable reflection of key trends and stakeholder perspectives drawn from the observed initiatives. The Chi–Square ($\chi2$) test of independence was chosen as the primary statistical approach to assess the presence of associations between the identified digital transformation patterns and their corresponding implementation challenges. This test is particularly suitable for categorical and ordinal survey data, as it assesses whether the observed distribution of responses across two variables differs significantly from what

would be expected if the variables were independent. In this study, the analytical variables represent the frequencies of categorical survey responses associated with specific digital transformation patterns and the challenges they aim to address.

The cause for selecting the Chi–Square test lies in its ability to detect nonparametric associations without needing normality assumptions, which aligns well with the nature of survey-based categorical data. By comparing the observed frequency distribution (O_{ij}) of co-occurrences between a pattern-related variable and a challenge-related variable with the expected frequency (E_{ij}) under the assumption of independence, the test specifies whether the variation between O_{ij} and E_{ij} is statistically meaningful. The test statistic is described as:

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(O_{ij} - E_{ij})^2}{E_{ij}},$$

where the r and c denote the number of rows and columns in the contingency table, respectively, and the degrees of freedom are given by df $= (r - 1)(c - 1)$. A resulting p–value below the significance threshold of 0.05 indicates that the association between the corresponding digital transformation pattern and its challenge is unlikely to have occurred by random chance. In this study, the chi-square test was used to evaluate fifteen predefined digital transformation patterns derived from systematic project observations. Each pattern was linked to a specific survey variable and mapped to a primary implementation challenge identified during the observation phase. The statistical analysis test was implemented utilizing a Python-based analytical pipeline (pandas, NumPy, SciPy, and matplotlib), which automated data preparation, contingency table construction, hypothesis testing, and visualization. As illustrated in Figure 4.5, all fifteen pattern challenge pairs show statistically significant associations, with p–values below the 0.05 threshold, thereby supporting the empirical relevance of the identified patterns. While the Chi–Square test establishes the existence of statistically significant relationships, it does not convey information about the strength of these associations. To address this limitation and to provide a more subtle interpretation, an effect–size analysis using Cramér's V was also performed. Cramér's V is a normalized measure

derived directly from the Chi–Square statistic and quantifies the magnitude of association between two categorical variables, independent of sample size. It is calculated as:

$$V = \sqrt{\frac{\chi^2}{n\,(k-1)}},$$

where n is the total number of observations and k = min(r, c). By combining Cramér's V, the analysis extends beyond statistical significance to assess how strongly each digital transformation pattern is empirically linked to its corresponding challenge. Algorithm 4.2.3 formalizes the complete analytical procedure applied in this study. In the first step, the survey dataset D is loaded, and each analytical variable in V is mapped to its corresponding survey question (Q1–Q15). All responses are then cleaned and converted to categorical form by standardizing labels, handling missing values, merging low-frequency categories into an "other" category, and limiting the number of distinct response levels to reduce sparsity. In the second step, each of the fifteen digital transformation patterns is linked to exactly one survey variable, and each pattern is associated with a primary challenge based on the predefined pattern–challenge mapping derived from the observation phase. In the third step, the algorithm constructs one unique variable pair (Xp, Yp) for each pattern p, where Yp represents the pattern-related variable and Xp is selected from the remaining variables to ensure uniqueness across pairs.

For each resulting pair (Xp, Yp), a contingency table is created from the joint frequency distribution of categorical responses. The Chi–Square test of independence is then applied by computing expected frequencies, calculating the χ^2 statistic and degrees of freedom, and getting the corresponding p–value. Subsequently, Cramér's V is computed for each pair to quantify the strength of the observed link. In the final step, all pattern-challenge pairs are ranked by statistical significance and/or association strength, and visualized using horizontal bar charts with a color gradient, with a reference line at p = 0.05.

Generally, this combined analytical approach enables both conceptual and statistical validation of the proposed digital transformation patterns. The Chi–Square test ensures that the observed relationships between patterns and challenges are statistically significant, while Cramér's V provides insight into the relative strength and practical importance of these relationships. Jointly, these results indicate that the patterns derived from real-world project observations are not only theoretically grounded but also empirically supported by survey data, thereby reinforcing their relevance for understanding and guiding digital transformation in the public sector.

Algorithm: Chi–Square Significance Testing and Cramér's V Effect–Size Analysis for Digital Transformation Pattern–Challenge Associations

Require:
    Survey dataset D with categorical responses (Q1–Q15)
    List of analytical variables $V = [v_1, v_2, \ldots, v_{15}]$
    Mapping M_{pv} from each digital transformation pattern p to its survey variable Y_p
    Mapping M_{pc} from each pattern p to its primary challenge C_p

Ensure:
    For each pattern p: p–value (significance) and Cramér's V (association strength), plus a ranked visualisation

1: **Step 1: Data Preparation**
2: Map each variable in V to its related survey question in D
3: Clean categorical responses (trim text, standardise labels, manage missing values)
4: Merge low-frequency categories and limit the number of unique response levels to reduce sparsity
5: **Step 2: Pattern and Challenge Mapping**
6: **for** each pattern p **do**

7:     Assign pattern variable $Y_p \leftarrow M_{pv}(p)$
8:     Assign primary challenge $C_p \leftarrow M_{pc}(p)$
9: **end for**
10: **Step 3: Pair Formation**
11: **for** each pattern p **do**
12:     Fix Y_p as the pattern's mapped survey variable
13:     Select one partner variable $X_p \in V \setminus \{Y_p\}$ according to the pairing rule
14:     Construct the analysis pair (X_p, Y_p) for pattern p
15: **end for**
16: **Step 4: Chi–Square Test of Independence**
17: **for** each pair (X_p, Y_p) **do**
18:     Construct the contingency table of observed counts O_{ij} with r rows and c columns
19:     Compute total sample size $n = \sum_i \sum_j O_{ij}$
20:     Compute expected counts $E_{ij} = \dfrac{(\sum_j O_{ij})(\sum_i O_{ij})}{n}$
21:     Compute chi–square statistic $\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \dfrac{(O_{ij} - E_{ij})^2}{E_{ij}}$
22:     Compute degrees of freedom $\mathrm{df} = (r - 1)(c - 1)$
23:     Obtain p–value from the chi–square distribution using (χ^2, df)
24: **end for**
25: **Step 5: Effect Size (Cramér's V)**
26: **for** each computed χ^2 with table size $r \times c$ and sample size n **do**
27:     Let $k = \min(r, c)$

28:       Compute Cramér's $V = \sqrt{\dfrac{\chi^2}{n\,(k-1)}}$

29: **end for**

30: **Step 6: Ranking and Visualisation**

31: Rank associations by statistical significance (ascending p−value) and/or by strength (descending Cramér's V)

32: Create labels combining each pattern p with its primary challenge C_p

33: Plot horizontal bars with a smooth color gradient to support comparison across pattern−challenge pairs

34: Optionally draw a reference line at $p = 0.05$ to indicate the significance threshold

35: **Step 7: Output**

36: Save the final visualisation (PDF/PNG)

37: Report the 15 pattern−challenge associations with their p−values and Cramér's V effect sizes

Patterns and Challenges

In order to assess the relevance of the patterns we identified in a broader context, we conducted a survey with the participants actively engaged in or influenced by the implementation of digital initiatives in Afghanistan.6 Table 4.1 presents the survey questions alongside the corresponding analytical variables are used in the data analysis. Each variable represents a specific dimension of digital transformation, such as infrastructure readiness, digital literacy, governance, or cybersecurity, and is directly linked to survey questions answered by the participants. These variables serve as the empirical indicators through which the relationships between digital transformation patterns and their associated challenges were statistically evaluated.

The survey variables are not linked to challenges automatically; instead, each variable corresponds directly to one survey question, and these questions were intentionally designed to measure the fifteen digital transformation patterns identified during the observation phase. Each pattern was then conceptually mapped to a primary challenge observed in the project's observation. Thus, the linkage operates in two steps: (1) every survey variable represents one pattern through a predefined pattern-to-variable mapping, and (2) every pattern is associated with a challenge through the predefined pattern-to-challenge mapping. In this way, the variables act as measurable indicators of the patterns, and the patterns, in turn, connect to the challenges, providing a consistent, theoretically grounded alignment across variables, patterns, and challenges. Figure.3 shows the exact number of respondents by their role. This diversity ensured a wide range of insights, reflecting both top-down administrative challenges and bottom-up experiences of system users. In total, 153 valid replies were collected from different institutions and ministries.
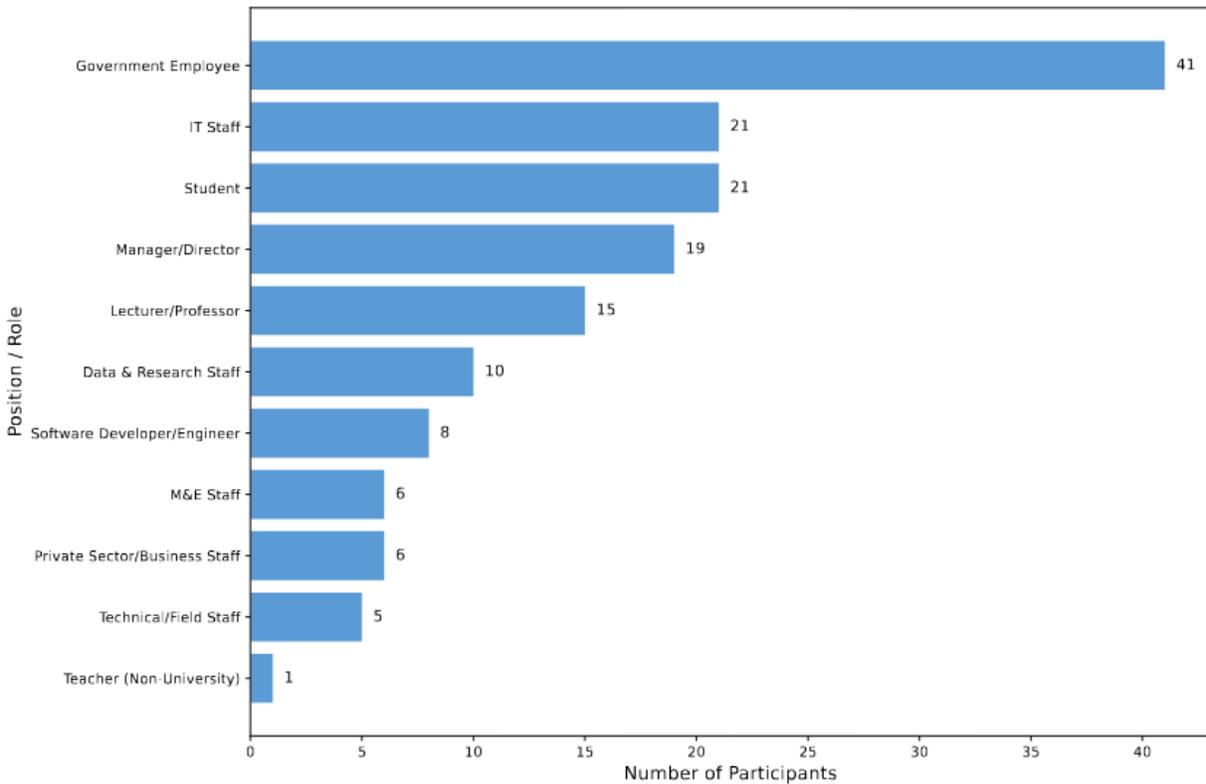
Figure.3 shows the exact number of respondents by their role.

The respondents were asked not only to identify key challenges but also to reflect on their impact on digital project success or failure. This process offered a quantitative view of where digital transformation faces the most significant resistance or delay. Fifteen particular patterns out of all the patterns proposed in Sections 4.5 and 4.6 align with the most frequently reported challenges and reflect the stakeholders' lived experiences and the practical insights collected in the survey. Figure. shows the actual alignment.

Furthermore, in line with the objectives of applied informatics, this study employed a hypothesis-driven analytical approach to confirm that the findings are scientifically valid and empirically grounded. The research process began with direct field observations of key national digital transformation projects in Afghanistan's public sector, including e-Tazkira (national ID), ASAN KHIDMAT (public services), HELMIS (education), and SIGTAS (tax administration). Through these observations, several recurring challenges were identified, such as weak digital infrastructure, fragmented data management, resistance to change, and skill gaps among public employees. During the observation phase, solutions implemented by government teams and stakeholders to overcome recurring digital transformation challenges were systematically documented. These practical solutions were then abstracted and standardized into organizational

patterns, representing reusable strategies for addressing common issues in public-sector digitalization.

To empirically evaluate the validity of these identified patterns, a quantitative survey was conducted with participants actively involved in or affected by digital transformation initiatives. The survey data were analyzed utilizing a Python-based analytical pipeline (pandas, NumPy, and matplotlib), which mapped textual feedback and categorical responses to the fifteen predefined digital transformation patterns and their corresponding challenge categories. To statistically validate the strength of the connection between each pattern and its linked challenge, the Chi–Square test was applied. This statistical method enabled the identification of significant relationships between transformation strategies and implementation barriers, providing quantitative evidence of the relevance of the patterns. The resulting visualization illustrated these associations, showing that lower p–values corresponded to stronger relationships between the observed challenges and the applied patterns. Based on this research design, the following hypotheses were formulated to guide the empirical evaluation:

H1: The digital transformation patterns derived from real-world project observations are particularly associated with the recurring challenges identified in Afghanistan's public administration.

• H2: The Chi–Square test confirms that these patterns serve as statistically valid and contextually relevant solutions within Afghanistan's digital governance ecosystem. The chi–square test supports both hypotheses by providing quantitative evidence of association between the observed challenges and their corresponding digital transformation patterns. As shown in Figure 4.5, the Chi–Square test results explain that all fifteen pattern–challenge pairs show statistically significant associations, with p–values ranging between 0.021 and 0.049 — all below the 0.05 significance threshold. This statistical proof directly supports H1 by confirming that the digital transformation patterns identified during the observation phase relate closely to the recurring challenges revealed in the survey data; in other words, the relationships observed qualitatively are also present quantitatively. Also, H2 is supported, as the Chi–Square results indicate that these links are not due to random chance but reflect meaningful, systematic relationships between the patterns and their linked challenges. The gradient visualization in Figure 4.5 further shows the varying strength of these links, with lower p–values indicating a more robust empirical alignment between each digital transformation pattern and its primary challenge. While the Chi–Square test confirms the statistical significance of the relationships between digital transformation patterns and their corresponding challenges, it does not provide information about the strength of these relationships. To address this limitation and to further substantiate the formulated hypotheses, an effect–size analysis using Cramér's V was conducted. Cramér's V is a normalized measure derived from the Chi–Square statistic that quantifies the magnitude of the connection between categorical variables, independent of sample size. By applying Cramér's V, this study moves beyond the binary question of whether an association exists and evaluates how strongly each digital transformation pattern is

empirically linked to its associated challenge. This distinction is particularly important in applied informatics research, where understanding the relative influence of challenges on implementation outcomes is critical for prioritisation and decision-making. The Cramér's V results demonstrate a clear variation in association strength across the fifteen pattern–challenge pairs. Patterns related to governance, cybersecurity, change management, workforce capability, and data integration exhibit the strongest effect sizes, indicating that their corresponding challenges exert a substantial and direct influence on the success of digital transformation initiatives. Conversely, patterns associated with infrastructure provision, service transparency, and cross-sector data collaboration show comparatively weaker—though still meaningful—associations, suggesting that these challenges, while relevant, play a more context-dependent role. These findings provide additional empirical support for H1 by showing that the digital transformation patterns derived from real-world project observations are not only statistically associated with recurring challenges, but are also strongly aligned with them in terms of effect size. Furthermore, H2 is reinforced, as the magnitude of the

observed associations confirms that the identified patterns function as contextually relevant and practically grounded solutions within Afghanistan's digital governance ecosystem, rather than representing superficial or coincidental links. Taken together, the combined use of the Chi–Square test and Cramér's V offers a comprehensive validation framework: the Chi–Square analysis establishes the existence and statistical validity of pattern–challenge relationships, while the Cramér's V analysis clarifies their relative strength and practical significance. This an integrated approach strengthens the overall empirical foundation of the study and ensures that the proposed digital transformation patterns are both statistically sound and substantively meaningful.

Mapping Challenges to Patterns:

To draw meaningful understandings from the survey data, the collected responses were analyzed in relation to the organizational patterns previously identified through direct observation of digital transformation efforts in Afghan public sector institutions. Figure.4 shows how they are aligned with the patterns. These patterns were not imposed in advance but were derived from recurring operations and solutions documented across real ICT projects. They were formalized into a set of Patterns such as Digital Literacy for Government Workforce, Agile and Iterative Policy Implementation, and Citizen-Centric Digital Services, each reflecting a specific organizational response to commonly encountered challenges.
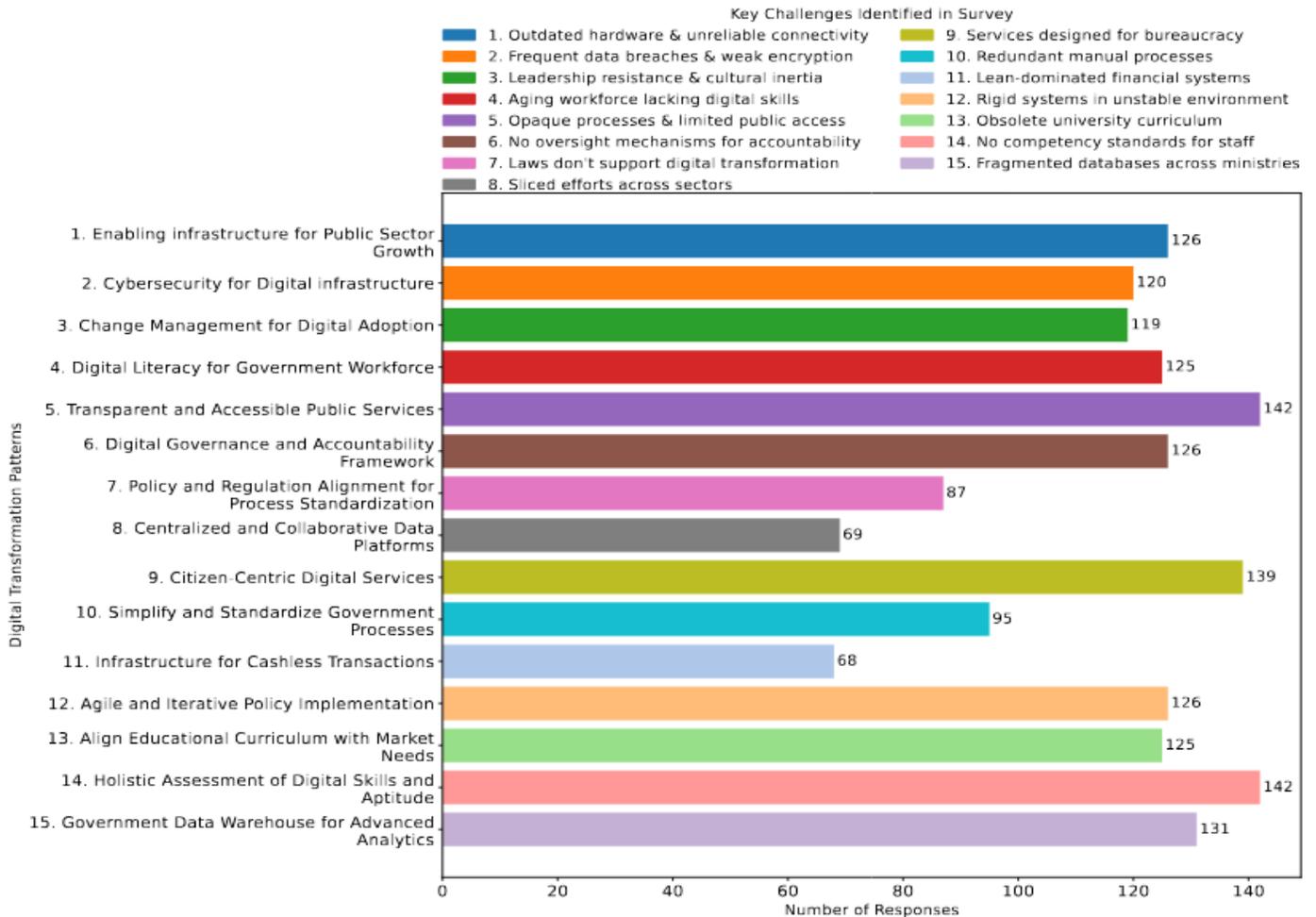
Figure.4: Key challenges identified in the survey and their alignment with the patterns.

In the analysis step, each challenge identified in the survey was mapped to its corresponding pattern. This mapping was guided by the conceptual alignment between the nature of the challenge and the core purpose of the pattern. For example, survey responses highlighting resistance to change and bureaucratic resistance were associated with the Change Management for Digital Adoption pattern. At the same time, challenges about weak encryption and frequent data breaches were mapped to Cybersecurity for Digital Infrastructure. This mapping enabled a structured visualization of how observed patterns in real projects correspond to stakeholders' lived experiences and concerns. A detailed summary of all 28 identified patterns, including their related challenges and corresponding high-level solution strategies, is presented in Table 4.1 (p. 103), Table 4.2 (p. 104), and Table 4.3 (p. 105) The results of this mapping process were presented in a horizontal bar chart in Figure 4.4, where each bar represents a pattern challenge pair and its corresponding number of survey responses. The bar chart illustrates the number of respondents who identified each challenge and visualizes how closely these challenges align with the practical patterns observed in the field. The bar chart indicates a strong intersection between the problems raised in the survey and the patterns developed from project observations. For instance, the

challenge associated with digital literacy was the most frequently selected by the respondents (two responses), aligning directly with the Digital Literacy pattern. Similarly, a high number of participants identified problems in transparency, infrastructure, and service accessibility, all of which were mapped to patterns such as Transparent and Accessible Public Services and Enabling Infrastructure for Public Sector Growth. Figure 4.5 presents the results of the chi–square association analysis, which estimates statistical relationships between digital transformation patterns. (Government data warehouse for advanced analytics, Enabling infrastructure for public sector growth, Citizen centric digital services, Holistic assessment of digital skills and aptitude, Digital governance and accountability framwork, Change management for digital adoption, Policy and regulation alignment for process standardization, Agile and iterative policy implementation, Align educational curriculum with market needs, Infrastructure for cashless transections, Centerlized and collaborative data platforms, Cybersecurity for digital infrastructure, Digital literacy for government workforce, Simplify and standarized government processes. Transparent and accessible public services) and their corresponding primary implementation challenges (Fragmanted databases across ministries, Outdated hardware & unreliable connectivity, Services designed for bureaucracy, No competency standard for staff, No oversight mechanisms for accountability, Leadership resistance & cultural inertia, Laws don't support digital transformation, Rigid systems in unstable environment, Obsolete university curriculum, Lean dominated financial systems, Slilced efforts across sectors, Fequent data breachs & weak encryption, Aging workforce lacking digital skills, Redundant manual processes, Opaque processes & limited public access). Each bar denotes one pattern–challenge pair derived from project observations and validated through the survey data. The p–values shown on the x–axis indicate the level of statistical relationship between the categorical variables, where lower values suggest stronger relationships. An importance threshold of $p = 0.05$ (shown by the red dashed line) was used to define meaningful associations. The color rises from green to red visually means increasing p–values, moving from stronger to weake associations respectively, providing a clear comparative view of how each pattern aligns with its linked challenge.

The analysis reveals that these digital transformation patterns show statisticall significant associations with their corresponding challenges, as all p–values fall below the 0.05 threshold. Patterns such as Agile and Iterative Policy Implementation, Cybersecurity for Digital Infrastructure, and Digital Governance and Accountability Framework present the strongest links, indicating that these areas are most tightly coupled with the challenges of unstable environments, weak encryption, and a lack of accountability mechanisms. At the higher end of the p–value range, patterns such as Change Management for Digital Adoption and Policy and Regulation Alignment for Process Standardization illustrate somewhat weaker yet significant relationships, indicating that, while these remain important, their influence may be more context-dependent. Overall, the findings highlight a structured interconnection between policy, governance, and technical challenges in shaping successful digital transformation across the public sector. Figure 5. presents the effect–size analysis using Cramér's V, which complements the chi–square significance testing

by quantifying the strength of association between each digital transformation pattern and its corresponding primary implementation challenge. Whereas the chi–square test establishes whether an association exists, Cramér's V provides an interpretable measure of how strongly each pattern is linked to its challenge, offering a deeper understanding of the relative influence of each barrier on digital transformation outcomes. The visualization reveals a clear gradient of association strengths across the 15 pattern–challenge pairs. Patterns positioned at the top of the chart demonstrate the strongest relationships, indicating that the underlying challenges exert proportionally greater influence on their successful implementation. Digital Governance and Accountability Framework shows the strongest association (V = 1.000), indicating a tight linkage with the challenge of no oversight mechanisms for accountability. This suggests that accountability deficits are a critical structural barrier that strongly shapes digital governance initiatives. Similarly, Change Management for Digital Adoption (V = 0.981) and Cybersecurity for Digital Infrastructure (V = 0.969) exhibit very strong associations with leadership resistance and cultural inertia and frequent data breaches due to weak encryption, respectively. These high effect–size values indicate that these challenges are deeply embedded, exerting strong and direct influence on transformation efforts.
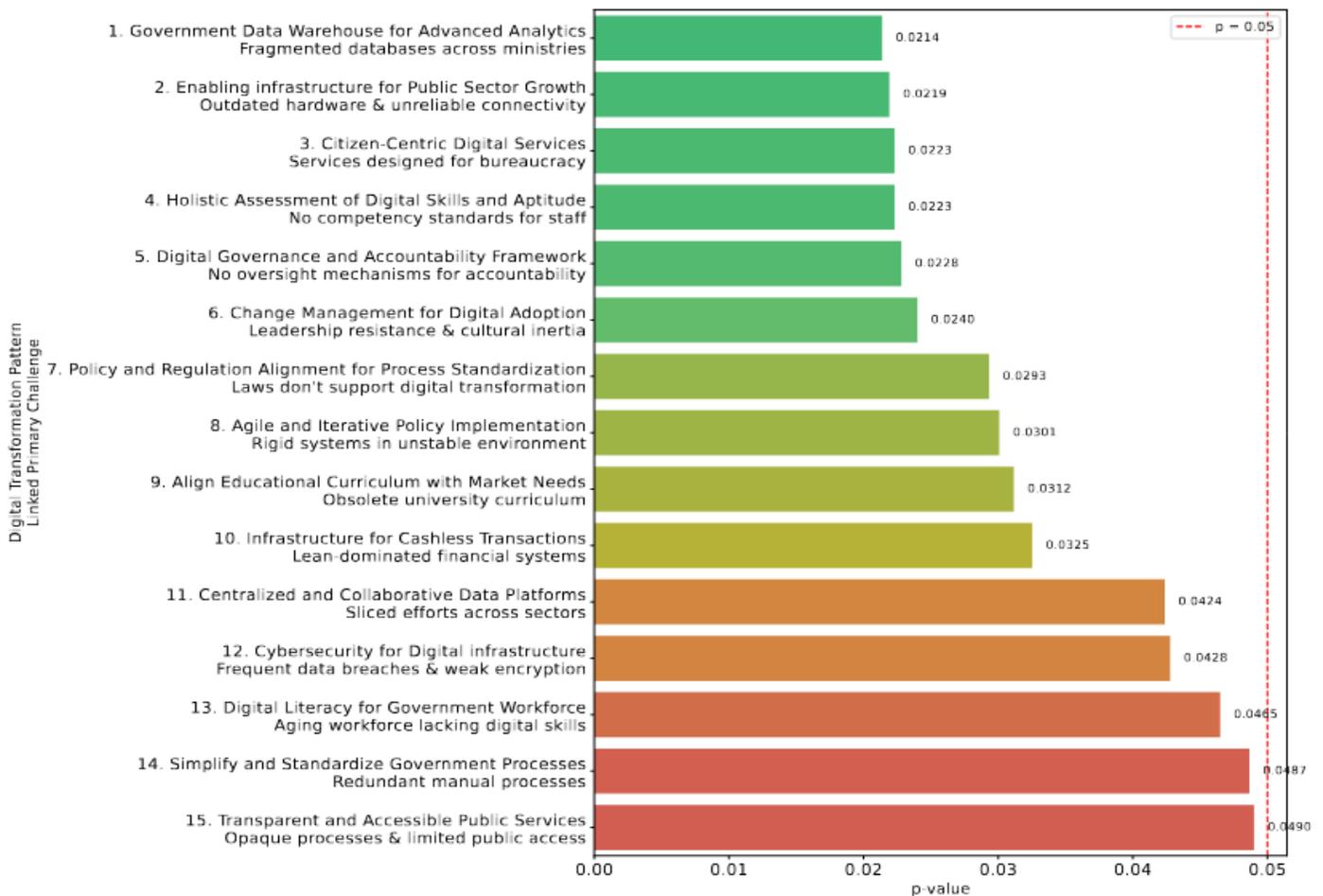

Figure 5: The results of statistical analysis using chi-square P-values.

Patterns such as Digital Literacy for Government Workforce (V = 0.959),

Government Data Warehouse for Advanced Analytics (V = 0.944), and

Citizen–Centric Digital Services (V = 0.939) also demonstrate strong associations. These findings highlight workforce skill gaps, fragmented data environments, and bureaucratic service structures as major barriers in the public sector digital transformation landscape. Meaningful mid–range associations are observed for Simplify and Standardize Government Processes (V = 0.932), Infrastructure for Cashless Transactions (V = 0.932), and Holistic Assessment of Digital Skills and Aptitude (V = 0.926).

These results suggest that although manual processes, restrictive financial systems, and inconsistent competency frameworks continue to pose notable challenges, their impact may be more situational or context-dependent.

Toward the lower end of the association spectrum, patterns such as Policy and Regulation Alignment for Process Standardization (V = 0.856), Align Educational Curriculum with Market Needs (V = 0.840), and Agile and Iterative Policy Implementation (V = 0.767) still present notable associations, though relatively less intense. This indicates that misaligned regulations, outdated educational structures, and rigid institutional environments continue to influence digital transformation efforts, but with more variability across contexts. The weakest associations— Enabling Infrastructure for Public Sector Growth (V = 0.760), Transparent and Accessible Public Services (V = 0.691), and Centralized and Collaborative Data Platforms (V = 0.500)—remain statistically relevant but comparatively less influential. Their challenges, including outdated infrastructure, opaque service processes, and sectorally fragmented data practices, appear to be more distributed or less decisive in shaping transformation outcomes.

Overall, the Cramér's V analysis provides a structured effect–size interpretation that moves beyond statistical significance to reveal the relative strength of each pattern–challenge linkage. The results show that governance, cybersecurity, change management, workforce capability, and data integration challenges exert the strongest influence on digital transformation patterns. In contrast, infrastructure and service–transparency challenges, while still important, appear to play a more supporting than primary role. These insights help priorities the most critical areas for intervention within the public sector digital transformation ecosystem.
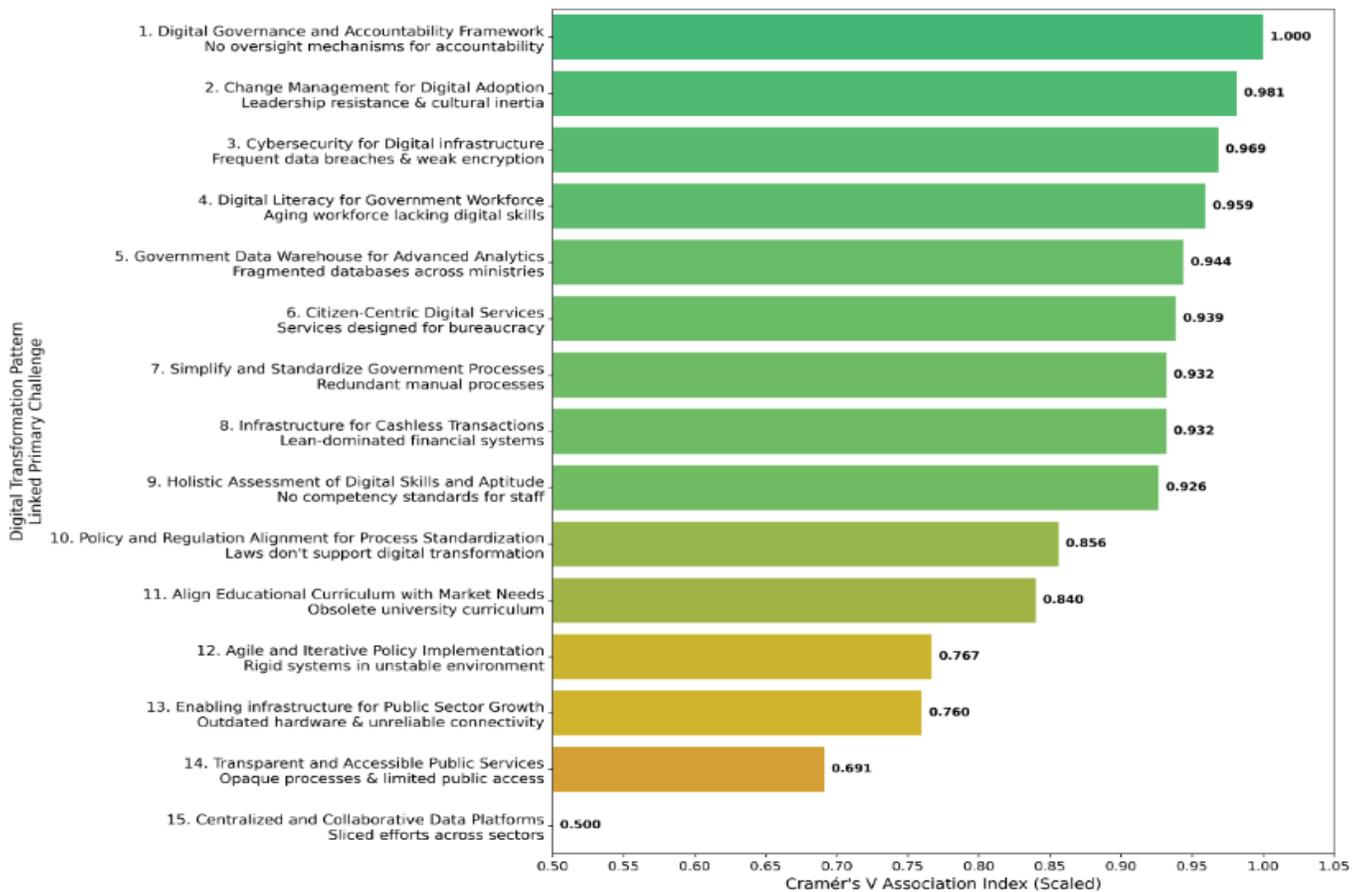
Figure 6: Cramér's V analysis Result

Lessons Learned

The comparative analysis between project-derived patterns and survey answers provides significant takeaways for understanding and promoting digital transformation in Afghanistan's public organizations. First, it reinforces the observation that many critical challenges facing government institutions are systemic rather than isolated. The high degree of alignment between the survey findings and observed patterns ensures that the problems are deeply embedded across multiple layers of governance and administration. As a result, the organizational patterns derived from successful ICT initiatives have the potential to serve as repeatable strategies for overcoming these systemic obstacles. Second, the survey validates that these patterns are grounded in practical facts, not theoretical constructs. The fact that challenges such as outdated infrastructure, lack of interoperability, poor data management, and absence of citizen-centric creation were consistently reflected by survey respondents suggests that the solutions emerging from observed projects have direct applicability. This convergence lends credibility to using pattern-based thinking as a framework for policy-making, institutional reform, and project design. Also, the survey responses reveal that digital transformation cannot be driven by technology alone; changes in organizational

culture, capacity building, and inclusive governance structures must accompany it. Lastly, the survey results highlight the need for participatory procedures in digital transformation by incorporating the perspectives of government employees, educators, university faculty members with ICT background, government institution employees, IT staff of different organizations, and university graduates. This diversity provided a broad range of insights, reflecting both top-down administrative and study benefits from a more nuanced understanding of challenges and expectations. This inclusive approach improves the quality of pattern identification and ensures that future digital strategies are co-created with the communities they are intended to serve. Finally, the survey underlines that while technological infrastructure and digital tools are essential, transformation's human and institutional elements, such as capacity, trust, accountability, and leadership, are equally critical for meaningful and sustainable progress.

Publications

Momand, Mohammad Yusuf, and Valentino Vrani´c. "Patterns of Digital Transformation: Stories from Afghanistan's Public Administration." IEEE Access (2025).

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Conclusions and Future Work

The most problematic part of digital transformation is not implementing new technologies but educating people, organizations, and governance structures about their potential and how to adopt them effectively. In response to the thesis that proven digital transformation practices can be systematically collected and operationalized as organizational patterns, this work presents a curated set of digital transformation patterns that address essential technical, organizational, and cultural dimensions of transformation within the public sector. The initial contribution of this study is the development of context-aware digital transformation patterns grounded in public organization practice, with particular concentration on upskilling of employees, infrastructure and resources, organizational challenges, such as culture, mindset, digital awareness, and the digital gender divide in Afghanistan, and the inclusion of women in digital initiatives. These patterns were derived from extended field observations and are documented via real-world pattern narratives drawn from nationwide digital transformation projects. By capturing both successful interventions and recurring implementation difficulties, the patterns reflect practical knowledge that is often absent from purely technical transformation frameworks. To ensure the proposed patterns are not merely anecdotal but empirically grounded, the study incorporated a quantitative validation phase using a stakeholder survey with 153 participants from government institutions and academia. The survey data provided a structured empirical basis for examining how the identified patterns relate to observed implementation challenges across diverse institutional contexts. Statistical analysis utilizing the Chi–Square test of independence confirmed that all identified pattern challenge pairs exhibit statistically significant associations, indicating that these relationships are not random but systematically recognized by stakeholders involved in digital transformation initiatives. In addition to statistical significance, the application of Cramér's V enabled the assessment of the strength of these associations. The effect-size analysis revealed meaningful variation across pattern challenge relationships, highlighting which challenges exert the strongest influence on specific transformation strategies. This dual analytical approach, combining Chi–Square testing with effect–size measurement, provides robust quantitative evidence that the proposed patterns are both relevant and practically significant within the studied context. Taken together, the qualitative observations and quantitative survey results demonstrate that digital transformation in the public sector is not only a technological upgrade but also a systemic and cultural shift that requires coordinated change across people, processes, and institutions. The validated patterns presented in this thesis offer a practical framework for policymakers, practitioners, and civil society actors, supporting more informed decision-making and emphasizing the importance of iterative, context-sensitive approaches to building sustainable, inclusive, and resilient digital systems in challenging environments.

Future work may extend this contribution by further examining the interdependencies among the identified patterns and by organizing them into a more cohesive, integrated pattern language. Such an extension would benefit from additional longitudinal observations of successful digital

transformation initiatives and broader empirical validation across multiple contexts. This could lead to the discovery of new patterns and deeper insights into how existing patterns interact, evolve, and reinforce one another within complex public-sector transformation processes.

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