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Knowledge Transfer Practices in African Railway Infrastructure Projects: A Comparative Study of Kenya and Ethiopia

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Knowledge Transfer Practices in African Railway Infrastructure Projects: A Comparative Study of Kenya and Ethiopia

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ABSTRACT

Knowledge transfer (KT) is essential for developing sustainable local technical capabilities in large-scale railway infrastructure projects. However, the effectiveness of knowledge transfer remains constrained by linguistic, organizational, and institutional barriers, particularly in projects delivered through international Engineering, Procurement, and Construction (EPC) arrangements. This study comparatively investigates KT practices, effectiveness, and implementation challenges in Kenya's Standard Gauge Railway (SGR) and Ethiopia's Ethio–Djibouti Railway (EDR) and associated railway projects. A sequential explanatory mixed-methods research design was employed, combining questionnaire responses from 80 professionals (56 from Ethiopia and 24 from Kenya) with 10 semi-structured interviews. Descriptive statistics, Mann–Whitney U tests, and thematic analysis were used to examine the findings. Results indicate that training was the highest-rated knowledge transfer mechanism (M = 4.3), whereas documentation of lessons learned received the lowest rating (M = 3.9). Language barriers represented the most significant constraint (M = 4.2), followed by documentation deficiencies and staff turnover (approximately M = 4.0). Kenya recorded a higher training score than Ethiopia (4.5 versus 4.2), while Ethiopia reported more severe language barriers (4.3 versus 4.0). Approximately 30% annual staff turnover was identified as a major threat to organizational knowledge retention. The study introduces the concepts of externalization fragility and the knowledge retention threshold to explain the institutional limitations affecting sustainable knowledge transfer. It concludes that effective KT requires integrated training, multilingual documentation, staff retention, and enforceable contractual mechanisms.

Keywords: Knowledge Transfer; Railway Infrastructure; EPC Projects; Knowledge Retention; Institutional Capacity.

1. INTRODUCTION

Railway infrastructure development has become an important driver of economic transformation, regional integration, and international trade facilitation across Africa. Governments are increasingly investing in modern railway systems to improve transportation efficiency, strengthen logistics networks, reduce freight costs, and enhance connectivity between major economic centers and seaports. However, the sustainable development of railway infrastructure requires more than physical construction. It also depends on transferring technical expertise, engineering competencies, operational knowledge, and institutional management capabilities to local organizations. Consequently, knowledge transfer (KT) has become an important dimension of international infrastructure development and long-term project sustainability [1, 2].

International Engineering, Procurement, and Construction (EPC) contractors have played a significant role in delivering major railway infrastructure projects in developing countries. Chinese construction companies, in particular, have contributed through engineering expertise, construction technologies, equipment provision, and technical training. Although these investments create opportunities for technological learning, the extent to which transferred knowledge becomes embedded in local institutions remains a major concern. Recent research indicates that international construction projects experience difficulties in achieving effective knowledge transfer because of cultural differences, organizational structures, communication barriers, and variations in the willingness of individuals to share and acquire knowledge [3, 4].

Knowledge transfer refers to the processes through which technical information, professional skills, practical experience, and organizational capabilities are communicated, acquired, and applied across individuals, teams, and institutions. Drawing on organizational knowledge theory, knowledge encompasses both tacit knowledge, acquired through practical experience, and explicit knowledge, which can be codified through manuals, drawings, technical specifications, and databases [5]. In railway infrastructure projects, knowledge transfer occurs through formal training, workplace mentoring, on-the-job learning, technical workshops, collaborative problem-solving, engineering documentation, and operational demonstrations. These mechanisms are particularly important in specialized areas such as track construction, railway signalling, electrical installations, rolling-stock maintenance, safety management, and operational control.

Nevertheless, knowledge transfer in construction projects is challenging because project organizations are frequently temporary, with employees and technical specialists moving between projects and organizations. Consequently, valuable technical experience may remain concentrated among individual employees and expatriate specialists rather than becoming institutional knowledge. Recent construction management research identifies inadequate documentation, employee turnover, and fragmented knowledge management systems as significant threats to organizational learning and knowledge retention [4, 6].

Kenya and Ethiopia provide relevant comparative contexts for investigating these challenges. Kenya's Standard Gauge Railway (SGR), particularly the Mombasa–Nairobi section commissioned in 2017 and the subsequent extension to [5], represents a major railway modernization investment (Kenya Railways, n.d.). Similarly, Ethiopia's 656-kilometre Ethio–Djibouti Railway, constructed by Chinese contractors and commencing transport services in January 2018, provides an important connection between Addis Ababa and the Port of Djibouti (Ethiopian Railways Corporation, n.d.). Both projects introduced advanced railway technologies and engineering practices into local institutional environments, creating opportunities for technical learning and workforce development.

However, evidence from Ethiopia indicates that technology transfer has been constrained by language barriers, limited construction-stage training, institutional coordination challenges, and difficulties in establishing sustainable local technical capabilities [2, 3]. Similarly, research on Kenya's SGR identifies continuing concerns regarding the institutionalization of transferred technical skills and the development of local operational and maintenance capabilities [7]. Differences in technical standards, institutional arrangements, contractor relationships, and workforce development approaches further justify a comparative investigation of the two countries [8].

Three interconnected problems therefore warrant investigation. First, the effectiveness of formal training and mentoring remains uncertain because participation in training does not necessarily demonstrate independent technical competence. Second, linguistic and communication barriers may prevent local professionals from fully understanding specialized engineering concepts, operational procedures, and technical documentation [9-11]. Third, inadequate documentation

and workforce turnover threaten organizational memory, particularly when practical experience is not systematically captured and transferred to succeeding employees. These challenges demonstrate the distinction between transferring knowledge to individuals and embedding knowledge within permanent institutional systems [12-14].

The central research gap is the limited comparative empirical understanding of how knowledge transfer mechanisms operate and produce sustainable institutional capabilities under different railway development environments [15, 16]. Existing studies have examined technology transfer, construction management, and infrastructure development, but further investigation is needed to compare the effectiveness of formal and informal knowledge transfer practices in Kenya and Ethiopia. This study addresses this gap by examining knowledge transfer mechanisms, practitioners' perceptions of their effectiveness, and the institutional, linguistic, and organizational factors influencing their implementation [17, 18].

The study further contributes to construction management literature by proposing two context-specific analytical concepts: externalization fragility and knowledge retention threshold. Externalization fragility refers to the vulnerability of converting tacit technical knowledge into explicit, documented, and locally accessible knowledge when language support, documentation systems, and organizational procedures are inadequate [19]. Knowledge retention threshold refers to the minimum level of workforce continuity and organizational support required for transferred knowledge to become embedded in institutional memory and routine practices. These proposed concepts provide an additional analytical perspective for understanding why training investments may strengthen individual competencies without necessarily producing sustainable organizational learning. Accordingly, the research is expected to generate comparative empirical evidence and practical recommendations for improving knowledge retention, local technical capacity development, and the long-term sustainability of railway infrastructure projects in Africa [20].

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area of this research focuses on railway project practices in Kenya and Ethiopia, two leading countries in East Africa that have undertaken major investments in modern rail infrastructure. The geographical scope is illustrated by the railway corridors connecting key economic and administrative centers in both countries. In Kenya, the study examines the Standard Gauge Railway (SGR), which links the port city of Mombasa to Nairobi and extends further inland, forming a critical transport backbone for freight and passenger movement. This project is central to Kenya's Vision 2030 development agenda and regional trade facilitation within the East African Community. In Ethiopia, the study focuses on the Addis Ababa–Djibouti Railway, a strategic corridor that connects the capital city, Addis Ababa, to the port of Djibouti, providing the country with vital access to international markets. The railway significantly enhances import and export efficiency for a landlocked economy. Both countries were selected due to their comparable large-scale railway investments, reliance on foreign financing and expertise, and shared challenges in technology transfer, operational sustainability, and institutional capacity development. The study of Kenya and Ethiopia provides insights for improving future transport infrastructure development in East Africa, as shown in Figure 1.



Figure 1. Geographical location of the study areas

2.2 Research Design

This study employed a sequential explanatory mixed-methods design, combining quantitative questionnaire surveys (n = 80) and qualitative semi-structured interviews (n = 10). Quantitative data were analyzed first to identify patterns and trends, which subsequently informed the qualitative interview questions. The interviews explored underlying explanations for the survey findings, including low B2 scores in documentation proficiency, which guided follow-up questions to Respondents 8–10. The Kenya–Ethiopia comparison was descriptive rather than inferential due to sample imbalance and contextual differences. Findings from both strands were integrated during analysis, as shown in Figure 2.

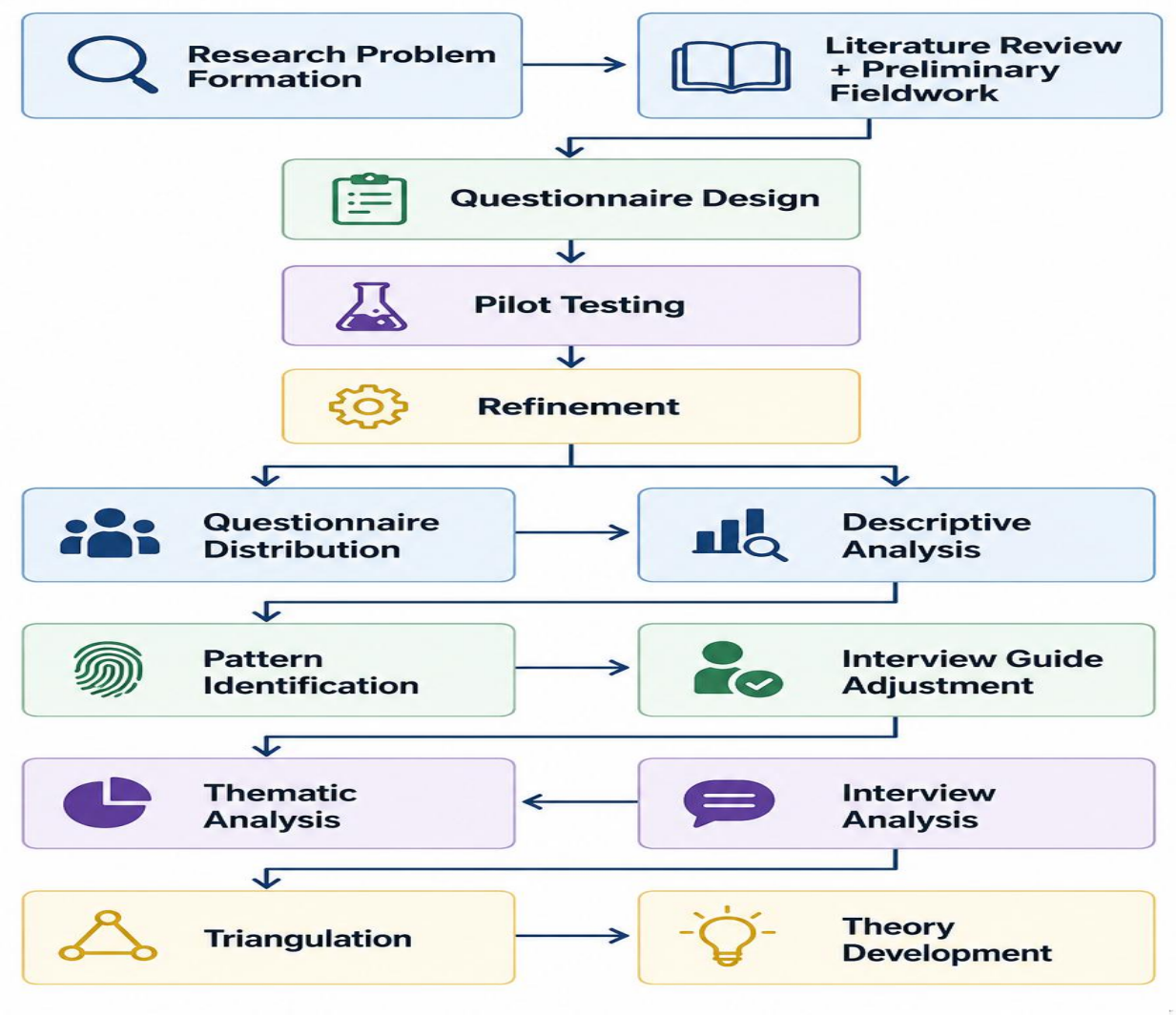

Figure 2. Sequential explanatory mixed-methods research framework

2.3 Target Population and Sampling Techniques

The target population consisted of professionals directly involved in railway construction and operational activities in Kenya and Ethiopia, including engineers, project managers, government officials, contractors, consultants, training coordinators, technical supervisors, and railway operations personnel. Purposive sampling was employed to select participants with relevant professional experience and knowledge of railway infrastructure development and knowledge transfer practices. Additionally, snowball sampling was used to identify further eligible respondents through professional networks and referrals. This combined sampling approach ensured the inclusion of participants with appropriate expertise and practical insights. The final quantitative questionnaire survey comprised 80 respondents from the two countries using equation 1.

$$n_{adjusted} = \frac{n}{\text{response rate}} \quad (1)$$

The 80 questionnaire respondents, 56 (70%) were from Ethiopia, while 24 (30%) were from Kenya. Ethiopia therefore accounted for the larger proportion of participants, reflecting the sample distribution across the two railway project contexts. This distribution provided a basis for descriptive cross-country comparison, as shown in Table 1.

Table 1. Distribution of questionnaire respondents

Country	Respondents	Percentage
Ethiopia	56	70.0
Kenya	24	30.0
Total	**80**	**100.0**

2.4 Data Collection Instruments

Primary data were collected through structured questionnaires and semi-structured interviews. The questionnaire comprised five sections covering respondent demographics, knowledge transfer practices, associated challenges, perceived impacts and benefits, and open-ended questions. Closed-ended items used a five-point Likert scale ranging from 1 (strongly disagree)

to 5 (strongly agree). Questionnaires were administered through Google Forms (34 responses) and paper-based distribution (46 responses). Additionally, ten semi-structured interviews were conducted with six Ethiopian and four Kenyan participants, lasting 30–75 minutes. Secondary data were obtained from railway project reports, commissioning documents, maintenance manuals, project contracts, relevant legislation, and academic publications.

2.5 Variables and Measurement Framework

The study examined three principal dimensions: knowledge transfer practices, implementation challenges, and perceived impacts. Knowledge transfer practices were measured using five indicators (B1–B5), covering knowledge-sharing encouragement, documentation of lessons learned, training provision, communication tools, and collaborative learning. Implementation challenges were assessed through four indicators (C1–C4), including cultural differences, language barriers, inadequate documentation, and staff turnover. Perceived impacts were evaluated using three indicators (D1–D3), focusing on improvements in project performance, reductions in cost overruns, and minimization of schedule delays. These indicators provided a structured framework for assessing knowledge transfer effectiveness and associated challenges in Kenyan and Ethiopian railway projects.

2.6 Quantitative Data Analysis

Descriptive statistics, including means and standard deviations, were used to summarize the study variables. The Mann–Whitney U test, standardized Z-scores, two-tailed p-values, and effect sizes were calculated to explore potential differences between Kenya (n = 24) and Ethiopia (n = 56). Spearman's rank-order correlations were computed for the full sample. Given the non-probability sampling approach and unequal subgroup sizes, all cross-country comparisons were interpreted descriptively rather than inferentially. A sensitivity analysis excluding Ethiopian government employees (n = 42) indicated consistent directional patterns, although reduced sample sizes limited reliability. Accordingly, findings remain exploratory and require validation through larger, balanced samples. The mean score was calculated using Equation (2). The standard deviation was calculated using Equation (3). The Mann–Whitney U test was used to examine differences between the Kenyan and Ethiopian respondent groups. Its general formulation is Equation (4), and the standardized test statistic was interpreted using the normal approximation in Equation (5).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{2}$$

$$SD = s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \tag{3}$$

$$U = \min(U_1, U_2) \tag{4}$$

$$\sigma_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}} \tag{5}$$

For interpretation, effect sizes were considered approximately small at (r=0.10), medium at (r=0.30), and large at (r=0.50). Because the sampling design was purposive and the country samples were unequal, the statistical comparisons were treated as exploratory descriptions of observed differences rather than evidence of population-wide differences.

2.7 Qualitative Data Analysis

The qualitative data were analyzed using Braun and Clarke's six-phase thematic analysis framework, comprising familiarization, initial coding, theme development, theme review, theme definition, and reporting. The dataset included ten semi-structured interviews and eighty open-ended questionnaire responses. Manual coding was employed instead of NVivo because the relatively small dataset permitted systematic examination of the original responses and detailed identification of recurring patterns. To strengthen analytical rigour and consistency, the researcher and a colleague from Mekelle University independently coded 20% of the interview transcripts, achieving 88% inter-coder agreement. Emerging themes were identified and refined based on their frequency, relevance, and interpretive significance. Particular attention was given to language barriers, communication failures, institutional constraints, documentation deficiencies, and knowledge retention challenges. The qualitative findings were subsequently compared with questionnaire results to identify areas of convergence and complementary insights. SPSS was used separately for quantitative data analysis and reliability testing, ensuring appropriate treatment of both datasets within the mixed-methods research design.

2.8 Reliability, Validity, and Triangulation

The reliability of the questionnaire was assessed using Cronbach's Alpha to evaluate the internal consistency of the knowledge transfer measurement scale. The scale comprised five items (k = 5), with a total item variance of 3.75 and total score variance of 11.43. Substitution into Equation (6) produced a Cronbach's Alpha coefficient of approximately 0.84, indicating good internal consistency and acceptable reliability for subsequent statistical analysis.

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right) \tag{6}$$

Content validity was established through expert assessment, pilot testing, and alignment of questionnaire items with established knowledge transfer literature. The Content Validity Index (CVI) was calculated using Equation (7), yielding 1.00 (100%), indicating unanimous agreement regarding item relevance. This demonstrates excellent content validity and appropriate coverage of the study constructs. Construct validity was further supported by aligning measurement indicators with the research objectives and theoretical framework.

$$CVI = \frac{N_a}{N} \tag{7}$$

Triangulation was employed to strengthen the credibility of findings by comparing quantitative survey results, qualitative interview evidence, and relevant project documents. The analysis examined convergence, complementarity, and divergence across the data sources. Four survey themes and five interview themes were identified and systematically compared based on their conceptual consistency. The findings demonstrated convergence across the principal themes, providing complementary evidence for interpreting knowledge transfer practices, implementation challenges, and perceived impacts in Kenyan and Ethiopian railway projects, Equation (8).

$$TCI = \frac{\text{Agreed Themes}}{\text{Total Themes Assessed}} \tag{8}$$

3. RESULTS AND DISCUSSION

3.1 Respondent Characteristics

The study combined questionnaire data from 80 respondents and interviews with 10 participants to provide quantitative and qualitative insights. Government employees constituted the largest group (52.5%), followed by contractors (22.5%), clients (15%), consultants (8.75%), and other stakeholders (1.25%). Integrating both methods strengthened contextual understanding and research credibility, as shown in Figure 3.

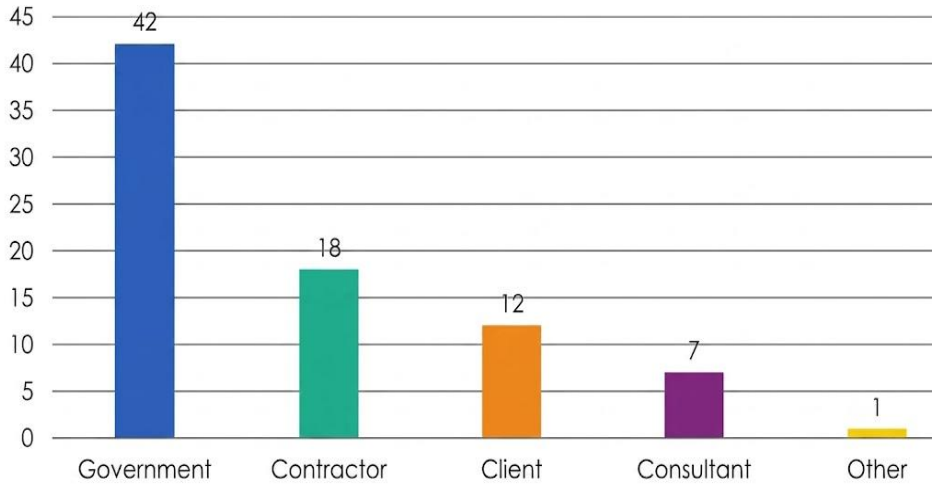

Figure 3. Profile of respondents by organization type distribution

3.2 Knowledge Transfer Practices

Training programs recorded the highest mean score (B3, M = 4.3), followed by knowledge sharing (B1, M = 4.2) and collaboration (B5, M = 4.1). Documentation scored lowest (B2, M = 3.9), highlighting weaknesses in knowledge retention, accessibility, and practical training effectiveness. The findings demonstrate that railway projects have established several formal and informal knowledge transfer mechanisms. Nevertheless, the comparatively low documentation score indicates that knowledge codification and long-term accessibility remain insufficiently institutionalized. An important distinction emerged between formal certification training and practical competency-based training. Interviews indicated that classroom-based instruction was more common, whereas sustained workplace mentoring, coaching, and practical demonstrations were comparatively limited, as shown in Figure 4.

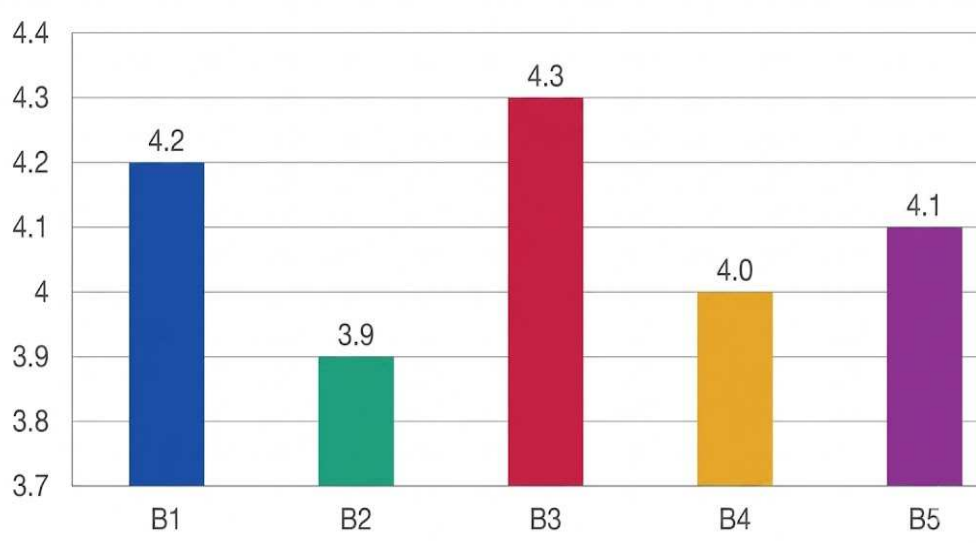

Figure 4. Mean Scores for Knowledge Transfer Practice (B1–B4)

3.3 Comparative Assessment of Kenya and Ethiopia

Kenya recorded higher mean scores across all five knowledge transfer practices, particularly training (B3: 4.5 vs. 4.2), documentation (B2: 4.1 vs. 3.8), and collaboration (B5: 4.3 vs. 4.0). These exploratory differences suggest stronger institutional support and structured training arrangements in Kenya, although findings remain descriptive due to sampling limitations, as shown in Figure 5.

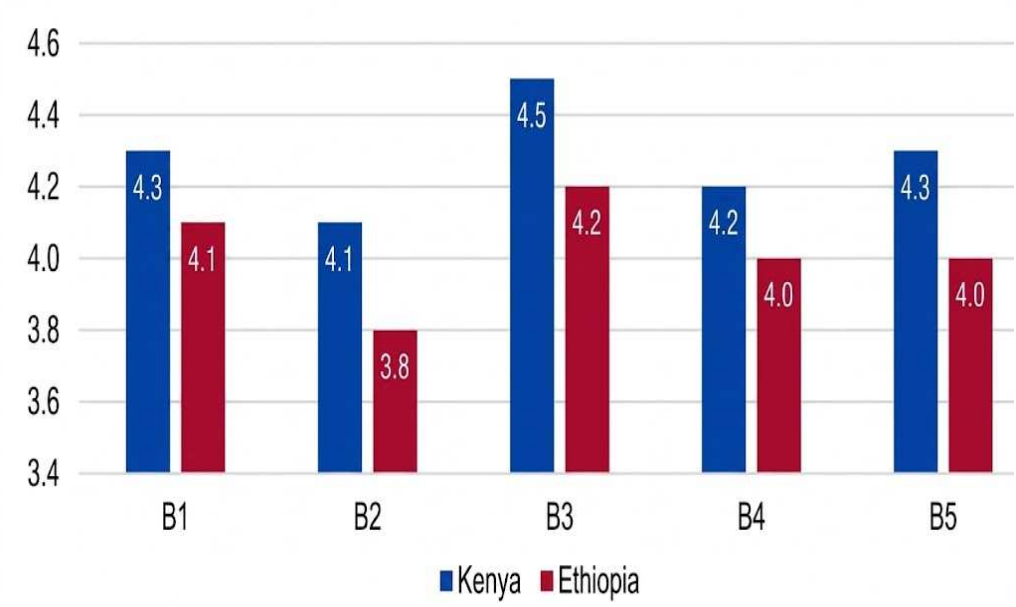

Figure 5. Comparison of Knowledge Transfer Practices (B1-B5)

3.4 Knowledge Transfer Challenges

Ethiopia reported greater knowledge transfer challenges than Kenya, particularly language barriers (4.3 vs. 4.0; r = 0.31), documentation deficits (4.1 vs. 3.8; r = 0.25), and cultural differences (3.6 vs. 3.2). These differences reflect Ethiopia's multilingual working environment, although sensitivity analysis confirmed broadly consistent patterns after excluding government respondents, as shown in Figure 6.

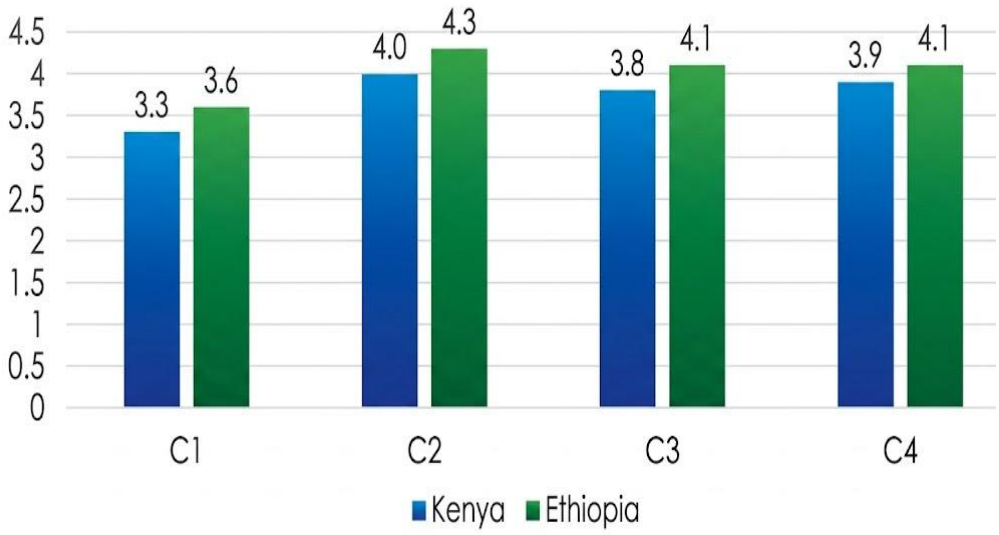

Figure 6. Comparison of Knowledge Transfer Challenges (C1-C4)

3.6 Perceived Impacts of Knowledge Transfer

Respondents generally recognized the importance of knowledge transfer for improving railway project performance. Project performance improvement achieved the highest overall mean score of approximately 4.6. Reduction of cost overruns and schedule delays also received favorable ratings. Country-level comparisons showed that Kenya recorded higher perceived benefits than Ethiopia across these three indicators, although the differences were relatively small and not statistically significant in the exploratory comparisons. An important finding is the gap between perceived benefits and actual implementation. Although respondents strongly recognized the value of KT, documentation, knowledge retention, and workplace application remained weak.

This indicates that recognizing the importance of knowledge transfer is not equivalent to establishing effective institutional systems for implementing it.

The findings indicate that knowledge transfer has a very high perceived impact on railway project performance. Improvement in project performance recorded the highest overall mean (D1, M = 4.6), followed by reduction in cost overruns (D2, M = 4.5). Reduction in schedule delays also received a very high rating (D3, M = 4.4). These results suggest that effective knowledge transfer contributes substantially to improved project implementation, financial efficiency, and timely completion. The consistently high mean scores demonstrate respondents' strong agreement regarding the benefits of knowledge transfer in enhancing construction project management outcomes, as shown in Figure 7.

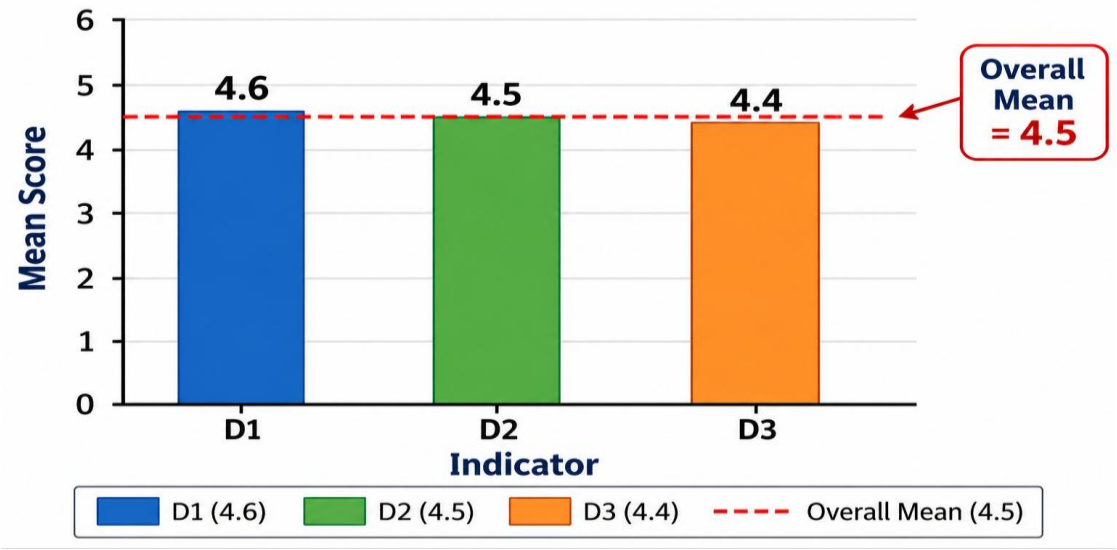

Figure 7. Perceived impacts of knowledge transfer

3.5 Interview Findings and Thematic Interpretation

Ten interviews were conducted with six Ethiopian and four Kenyan professionals, identifying six themes: formal versus practical learning, language barriers, weak documentation, fragmented technical standards, project-specific knowledge transfer, and the need for contractual accountability and management commitment. In the Weldiya–Mekelle railway project, an Amharic-annotated field guide enabled successful transfer of laser profiler procedures, which remained in use three years later. Conversely, untranslated Chinese-language alignment tolerance standards required repeated training for new employees. These contrasting cases demonstrate that effective knowledge transfer requires accessible documentation, appropriate translation, knowledge sharing, and institutionalization beyond individual projects.

4. CONCLUSIONS

The findings demonstrate that knowledge transfer (KT) contributes substantially to railway project performance in Kenya and Ethiopia. However, persistent documentation, linguistic, and institutional challenges limit sustainable knowledge retention. The principal conclusions, supported by the study findings, are summarized below:

1. The study included 80 questionnaire respondents and 10 interviewees, with government employees representing the largest group (52.5%).
2. Training received the highest overall rating (M = 4.3), followed by knowledge sharing (M = 4.2), while documentation scored lowest (M = 3.9).
3. Kenya recorded higher training (4.5 vs. 4.2) and documentation scores (4.1 vs. 3.8), indicating stronger reported KT practices.
4. KT challenges: Ethiopia reported greater language barriers (4.3 vs. 4.0) and documentation deficiencies (4.1 vs. 3.8).
5. KT positively influenced project performance (M = 4.6), cost control (M = 4.5), and schedule performance (M = 4.4).
6. The ten interviews highlighted six themes, demonstrating the need for practical training, multilingual documentation, contractual accountability, and workforce stability to institutionalize knowledge transfer

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