

## Article

# The Future of Humanitarian Logistics: How Donors and Volunteers Will Shape Supply Chain Cooperation in 2030

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## Abstract

**Background:** This study examines how humanitarian supply chain cooperation in Morocco may evolve toward 2030, focusing on the roles of donors, volunteers, and digital technologies in strengthening coordination, operational performance, and resilience in crisis environments. **Methods:** A mixed-methods approach was adopted, combining qualitative data collected through interviews and focus groups with 57 humanitarian actors and quantitative data obtained from 1183 logistics professionals. Regression analysis, analysis of variance (ANOVA), and qualitative foresight techniques were employed to explore current cooperation patterns and future humanitarian supply chain dynamics. **Results:** The findings indicate that donors are increasingly expected to support digital coordination, predictive planning, and capacity-building initiatives rather than acting solely as financial contributors, while volunteers continue to play a critical role in adaptive and decentralized operations, particularly in rural areas. The results further suggest that digital technologies may enhance visibility, responsiveness, and collaboration when integrated into human-centered governance systems. **Conclusions:** The study proposes an integrated socio-technical framework for understanding humanitarian supply chain cooperation toward 2030 and provides practical insights for developing resilient, collaborative, and future-ready humanitarian logistics systems in emerging economies.

**Keywords:** humanitarian logistics; supply chain cooperation; donor and volunteer engagement; technology adoption



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## 1. Introduction

Humanitarian logistics services have become an indispensable part of disaster response and relief operations worldwide, as they ensure that vital supplies such as food, water, medicines and shelter reach affected populations in a timely and efficient manner [1,2]. The complexity of these operations has increased in recent years due to global phenomena such as climate change, urbanisation, migration crises and the growing frequency of natural disasters [3]. According to United Nations humanitarian assessments, more than 300 million people required humanitarian assistance and protection worldwide in 2024, while global humanitarian funding requirements exceeded USD 45 billion [4].

Simultaneously, climate-related disasters, forced displacement, and socio-economic crises continue to increase both the frequency and complexity of humanitarian operations. As humanitarian needs expand and operational environments become increasingly uncertain, humanitarian organisations face growing pressure to improve coordination, resource utilisation, and supply chain responsiveness. Addressing these challenges requires not only operational efficiency but also close cooperation among governments, international and local non-governmental organisations, private organisations, donors, and volunteers.

Morocco represents an important context for analysing humanitarian logistics due to its geographical diversity, socio-economic disparities and exposure to disasters such as floods, droughts and earthquakes. While urban centres such as Casablanca and Rabat benefit from stronger infrastructure, rural and mountainous regions continue to face limited transport connectivity and fragmented distribution networks [5,6]. These conditions require humanitarian organisations to continuously strengthen supply chain coordination and adaptability. Donors influence operational priorities and flexibility through financial and strategic support [7], while local and international volunteers contribute through operational assistance, community engagement and local knowledge transfer [8]. However, previous studies generally analyse donors and volunteers separately and rarely examine their combined influence on humanitarian supply chain collaboration in Morocco.

The focus on the year 2030 is particularly relevant because it represents a strategic milestone for governments, humanitarian organisations, and international development agencies worldwide. This horizon is closely associated with the United Nations 2030 Agenda for Sustainable Development, which emphasizes resilience, sustainable infrastructure, inclusive partnerships, and effective disaster response systems. Furthermore, humanitarian organisations increasingly rely on medium- and long-term planning horizons extending toward 2030 to prepare for the expected impacts of climate change, demographic growth, urbanisation, resource scarcity, and geopolitical instability. Consequently, understanding how humanitarian supply chains may evolve toward 2030 has become both a managerial and research priority.

This study is also motivated by emerging trends expected to transform humanitarian logistics by 2030. Technologies such as artificial intelligence, predictive analytics, real-time tracking systems and digital volunteer coordination platforms are increasingly reshaping humanitarian operations. Additional innovations including blockchain-based traceability systems, cloud-based coordination platforms, advanced forecasting tools, autonomous delivery technologies, and data-driven decision-support systems are expected to further transform humanitarian logistics processes over the coming years. Collectively, these technological advances have the potential to improve visibility, coordination, transparency, and operational responsiveness while supporting more effective collaboration among humanitarian stakeholders. Despite their considerable potential, adoption remains uneven, particularly in North Africa. Understanding how donor expectations, volunteer engagement, and technological innovation interact is therefore essential for developing sustainable and adaptive humanitarian supply chains capable of addressing future challenges related to climate risks, population growth, and changing donor priorities.

Despite the growing importance of humanitarian supply chain cooperation, important research gaps remain. Existing studies have primarily examined donor funding, volunteer engagement, technology adoption, or humanitarian performance as separate areas of investigation. Comparatively little attention has been devoted to understanding how these dimensions interact simultaneously within a unified framework capable of explaining the future evolution of humanitarian logistics systems. Moreover, empirical evidence from Morocco remains limited despite the country's increasing exposure to environmental, social, and logistical challenges requiring coordinated humanitarian responses. Addressing

these gaps is particularly important given the growing need for resilient and collaborative humanitarian supply chains capable of responding effectively to future crises.

The originality of this study lies in its integrated and forward-looking methodological approach. Unlike previous studies focusing separately on operational, financial or volunteer dimensions, this research combines donors, volunteers and inter-organisational collaboration within a unified analytical framework. Using a mixed-method approach integrating quantitative surveys analysed through SPSS with qualitative interviews and focus group discussions, the study provides deeper insights into stakeholder interactions and contributes new knowledge on strengthening the resilience, coherence and effectiveness of Morocco's humanitarian supply chain toward 2030.

The importance of the present study is justified by both practical and theoretical considerations. Humanitarian organisations are increasingly required to improve coordination, accountability, operational efficiency, and resilience while operating under resource constraints and growing uncertainty. At the same time, limited knowledge exists regarding the combined influence of donors, volunteers, and emerging technologies on humanitarian supply chain cooperation and future preparedness. Addressing this gap is therefore essential for advancing both managerial practice and academic understanding.

This study has four main objectives: (1) document current patterns of cooperation and supply chains among humanitarian actors in Morocco; (2) assess the impact of donors and volunteers on operational efficiency and integration; (3) identify barriers and enablers to effective collaboration; and (4) explore strategic approaches to strengthening supply chain resilience and adaptability in order to meet the challenges of 2030. This study achieves the above objectives by focusing on the following research questions: the impact of donors, the contribution of volunteers, the challenges and facilitators of collaborative practices, and the strategies required to strengthen the sector over the next decade. In addressing these issues, this study fills a critical gap in the literature and presents the first empirical study conducted in Morocco that integrates the impact of donors, the involvement of volunteers, and collaboration among various actors within a forward-looking and technology-enhanced framework.

The remainder of this article is structured as follows. The next section presents the literature review relating to humanitarian logistics, donor involvement and volunteer collaboration. Section 3 outlines the research methodology, followed by the data analysis and results, discussion and implications, and finally Section 6 concludes with the findings and contributions.

## 2. Literature Review

Humanitarian logistics has evolved into a specialised field dedicated to delivering aid supplies—including food, medicines and emergency relief equipment—to crisis-affected populations in a timely and effective manner [9,10]. Unlike commercial supply chains, where maximising profit and efficiency are the primary objectives, humanitarian supply chains operate in environments characterised by high uncertainty, limited resources and constantly changing infrastructure, and are often situated within complex socio-political contexts [11]. Cooperation is key to achieving operational efficiency, which requires effective coordination of logistical activities (such as transport and warehousing) and the integration of information flows among various actors—including government agencies, international and local non-governmental organisations, private-sector donors and community organisations. Cooperation also involves joint decision-making, trust-building and the alignment of strategic objectives, which help reduce duplication of effort and improve response capacity during crises [12–14].

In Morocco, these challenges are intensified by geographical and socio-economic diversity, ranging from urban centres such as Casablanca and Rabat to remote rural and mountainous areas facing limited infrastructure and communication networks [15,16]. Humanitarian organisations must therefore coordinate multiple actors with differing priorities and operational capabilities, while strengthening trust, communication and knowledge-sharing mechanisms to improve resilience and adaptability within interconnected supply chains [17–21]. Crises such as floods, droughts and urban emergencies further require flexible decision-making, real-time information exchange and proactive coordination between operational and strategic levels [22–25].

Donors and volunteers represent two essential pillars of humanitarian supply chains. Donors provide financial and material resources that shape organisational priorities, operational planning and accountability mechanisms [26,27]. Their decisions regarding funding allocation, reporting standards and compliance requirements directly influence organisational responsiveness and network resilience [28,29]. Volunteers contribute manpower, local knowledge and community engagement, particularly in rural and mountainous regions where culturally sensitive approaches are required [30–32]. Their effectiveness depends on adequate training, coordination and integration into organisational workflows, whereas poor management may create inefficiencies and operational risks [33]. The interaction between donors and volunteers is highly interdependent, as donor funding enables operational activities while volunteer performance influences donor perceptions regarding effectiveness and accountability [34,35]. Consequently, humanitarian supply chain performance depends not only on financial or human resources individually, but also on the coordination mechanisms linking both dimensions, including joint planning, information-sharing systems and standardised cooperation protocols that strengthen operational resilience and reduce delays during crises [36–39].

Humanitarian logistics is also being transformed by technological, societal and organisational innovations. Advanced digital tools such as artificial intelligence, predictive analytics, blockchain systems and cloud-based coordination platforms increasingly improve efficiency, transparency and responsiveness within humanitarian supply chains [40,41]. These technologies enable humanitarian organisations to monitor the flow of resources, optimise distribution routes, forecast needs more accurately and coordinate the actions of various stakeholders more effectively [42]. However, their successful implementation depends to a large extent on human factors and interpersonal relationships within the supply chain. Donor funding not only provides the financial resources for the introduction of such innovative technologies, but also shapes the scope, timing and monitoring mechanisms of their deployment [27]. Volunteers and local staff determine the practical usability of these technologies by adapting them to operational realities and local conditions [23,43]. In Morocco, the differences in infrastructure and digital accessibility between urban centres such as Casablanca and rural or mountainous areas underscore the need to develop context-sensitive strategies to align technology deployment with human capacity and operational requirements.

Robust communication channels, standardised reporting mechanisms and a shared situational awareness are crucial for coordinating human and technical resources, avoiding operational bottlenecks and maximising the impact of humanitarian interventions. A lack of integration between technological and human actors limits the benefits of digital innovations and leads to inefficiency and reduced responsiveness. Although the importance of technological and human factors is increasingly recognised, significant gaps remain in the relevant literature. Few studies examine the combined effects of donors, volunteers and the use of technology within a unified framework, particularly against the backdrop of complex geographical and social contexts such as those in Morocco. Most existing

studies deal in isolation with financial resources, human resources or technology, without, however, examining in depth how these factors collectively influence collaboration, efficiency and supply chain resilience. Looking ahead to 2030, humanitarian logistics is expected to face increasingly complex challenges due to climate change, population growth and evolving socio-political challenges.

The following section explains the research methodology and describes in detail the research design, data collection procedures and analytical techniques used in this prospective study.

### 3. Materials and Methods

This study adopts a combined quantitative and qualitative approach to assessing the development of cooperation in the Moroccan humanitarian logistics sector, emphasizing the contributions of donors and volunteers together with the use of information technology. A mixed-methods research design was selected because humanitarian logistics involves complex interactions among organizational, technological, and human factors that cannot be fully understood through a single methodological approach [44]. Consistent with [45], the integration of qualitative and quantitative methods enables methodological triangulation and provides a more comprehensive understanding of humanitarian supply chain cooperation. While the qualitative phase offers rich contextual insights into stakeholder experiences and future expectations, the quantitative phase allows the empirical examination of relationships among donor engagement, volunteer involvement, technology adoption, and operational performance.

The study was carried out in different regions of Morocco, especially Casablanca and Rabat, with the aim of reflecting the diversity of humanitarian missions. This choice can be justified by their high population density, highly developed transport infrastructure, clustering of humanitarian organisations, the existence of solid volunteer programmes, as well as their high level of technological integration. The study also included some rural and mountainous zones in the north and south of Morocco, where the inhabitants are spread out, access is difficult, facilities are lacking, and activities rely heavily on volunteers and flexible coordination systems. Such diversity of environments enhances the validity and generalisability of the findings and aligns with the literature's recommendations regarding the need to adopt context-sensitive approaches in humanitarian supply chain research.

#### 3.1. Qualitative Research

The qualitative research phase aimed to explore stakeholders' experiences, perceptions and strategies regarding humanitarian logistics cooperation in Morocco. A purposive sample of 57 participants was selected, including NGO operations managers, volunteer coordinators, donor representatives, local government officials, and field volunteers. Participants were chosen according to their direct involvement in humanitarian operations, their expertise in coordination mechanisms, and their experience with technology-based logistics practices. The sample was designed to ensure diversity in organizational roles, operational responsibilities, and geographical contexts. The study included stakeholders operating in both urban and rural environments, thereby capturing a broad range of humanitarian logistics experiences and perspectives. Data collection continued until theoretical saturation was achieved, meaning that additional interviews and focus group discussions generated limited new insights.

The data were gathered using semi-structured interviews and focus groups (each comprising 6 to 8 participants) during the period between June and August 2025. Discussions with participants focused on their professional experience, engagement with

donors, coordination of volunteers, deployment of technology, and future scenarios for humanitarian logistics performance by 2030. The interviews and group discussions took place in Arabic, French, or English according to participants' preferences. All interviews were recorded with participants' consent and transcribed verbatim.

Qualitative data were analysed using thematic analysis, a method combining inductive and deductive coding. Deductive coding was based on the literature and covered themes such as donor influence, volunteer engagement, technology integration, and process coordination, whereas inductive coding emerged directly from participants' experiences and operational practices.

The thematic analysis followed the procedures proposed by [44], including data familiarization, initial coding, theme generation, theme review, and theme definition. Axial coding was employed to identify relationships between operational practices, stakeholder collaboration, and technology adoption, while selective coding was used to verify alignment between emerging themes and the research objectives. The analytical process was further guided by established qualitative research quality criteria emphasizing transferability, dependability, and confirmability.

The credibility and trustworthiness of the qualitative findings were strengthened through the use of multiple data collection techniques, including interviews and focus groups, as well as triangulation across participant categories. The inclusion of donor representatives, NGO managers, volunteer coordinators, local authorities, and field volunteers enabled the comparison of multiple perspectives and enhanced the robustness of the interpretations.

### 3.2. Quantitative Research

The quantitative phase comprised an empirical study designed to explore the relationships between donor engagement, volunteer involvement, technology adoption, and operational performance. Based on a carefully designed sampling strategy targeting individuals with operational experience and knowledge of humanitarian logistics practices, a questionnaire survey was conducted with 1183 valid respondents drawn from different stakeholder groups involved in humanitarian operations.

The sample size was considered appropriate for the objectives of the study and substantially exceeds commonly recommended thresholds for correlation analysis, analysis of variance (ANOVA), and multiple regression analysis, thereby providing adequate statistical power for the empirical investigation.

Data collection used a structured questionnaire distributed both online and in paper format to maximize response rates and reduce response bias. A total of 1278 questionnaires were collected. Following the screening process, 95 questionnaires were excluded due to incomplete responses, excessive missing data, inconsistent response patterns, and duplicate submissions. The final dataset therefore consisted of 1183 valid questionnaires, which were retained for the statistical analysis.

The questionnaire comprised five sections covering demographic information, donor contributions, volunteer engagement, technology adoption, and operational performance indicators. It included Likert-scale items, multiple-choice questions, and scenario-based questions reflecting real-world humanitarian operational challenges.

Prior to large-scale distribution, the questionnaire was pilot-tested with 20 humanitarian logistics practitioners, including NGO staff members, volunteer coordinators, and field personnel. Feedback obtained during the pilot phase resulted in minor revisions to item wording, question sequencing, and contextual clarity, thereby improving the readability and relevance of the instrument. Participation in the study was entirely voluntary, and respondents were informed about the objectives of the research. Confidentiality

and anonymity were guaranteed throughout the data collection and analysis process, and all responses were used exclusively for academic purposes.

The measurement instrument was developed specifically for this study based on the findings of the qualitative phase. Four constructs were measured, namely Donor Engagement (4 items), Volunteer Involvement (4 items), Technology Adoption (6 items), and Operational Performance (8 items). The measurement items were designed to reflect the Moroccan humanitarian logistics context and the future-oriented focus of the study toward 2030. A complete list of measurement items is provided in Table 1.

**Table 1.** Constructs and Measurement Items.

| Construct                    | Code | Measurement Items (5-Point Likert Scale: 1 = Strongly Disagree, 5 = Strongly Agree)                  |
|------------------------------|------|------------------------------------------------------------------------------------------------------|
| Donor Engagement (DE)        | DE1  | Donors maintain continuous exchanges with our organization regarding ongoing logistical operations.  |
|                              | DE2  | Decisions related to logistics and field operations are shaped by donor input.                       |
|                              | DE3  | The reporting and accountability procedures requested by donors are well structured and transparent. |
|                              | DE4  | Donor funding arrangements allow operational teams to adapt when unexpected situations arise.        |
| Volunteer Involvement (VI)   | VI1  | Volunteers are actively involved in the execution of logistics and distribution activities.          |
|                              | VI2  | Volunteers are sufficiently prepared and trained to carry out their assigned tasks.                  |
|                              | VI3  | Collaboration between volunteers and professional staff is well organized and effective.             |
|                              | VI4  | The organization succeeds in maintaining a stable pool of experienced volunteers.                    |
| Technology Adoption (TA)     | TA1  | Digital systems are used to monitor the movement and availability of humanitarian supplies.          |
|                              | TA2  | Software tools support planning and coordination of transport and delivery operations.               |
|                              | TA3  | Digital platforms facilitate interaction and coordination among donors, managers, and volunteers.    |
|                              | TA4  | Advanced analytical or AI-supported tools are used to assist operational decision-making.            |
|                              | TA5  | The technological tools employed are accessible and easy to handle for both staff and volunteers.    |
|                              | TA6  | Digital technologies are effectively embedded in everyday humanitarian logistics activities.         |
| Operational Performance (OP) | OP1  | Humanitarian deliveries are carried out within acceptable timeframes.                                |
|                              | OP2  | Financial, material, and human resources are used efficiently during operations.                     |
|                              | OP3  | The organization is able to react quickly to emergency situations.                                   |
|                              | OP4  | Collaboration among stakeholders improves overall operational effectiveness.                         |
|                              | OP5  | Logistical disruptions are managed effectively when they occur.                                      |
|                              | OP6  | Operations remain functional despite infrastructural or environmental constraints.                   |
|                              | OP7  | The use of digital tools contributes positively to operational efficiency.                           |
|                              | OP8  | Overall humanitarian logistics activities achieve their intended objectives.                         |

Quantitative data were analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Data cleaning procedures included the identification of missing values, outliers, and inconsistent responses. Descriptive statistics were used to summarize participant characteristics and operational profiles, while inferential analyses, including correlation analysis, multiple regression analysis, and analysis of variance (ANOVA), were employed to examine relationships among donor engagement, volunteer involvement, technology adoption, and operational performance.

Prior to conducting ANOVA and multiple regression analyses, the underlying statistical assumptions were examined through normality and multicollinearity diagnostics in order to verify the suitability of the dataset for the selected analytical procedures. Cronbach's Alpha was used to assess the reliability of the multi-item scales. The integration of qualitative and quantitative findings enabled a comprehensive comparison of narrative perspectives and statistical evidence, providing a deeper understanding of collaborative mechanisms in Moroccan humanitarian logistics. Figure 1 presents the overall research process, including the qualitative phase, quantitative phase, data analysis procedures, and integration of findings.

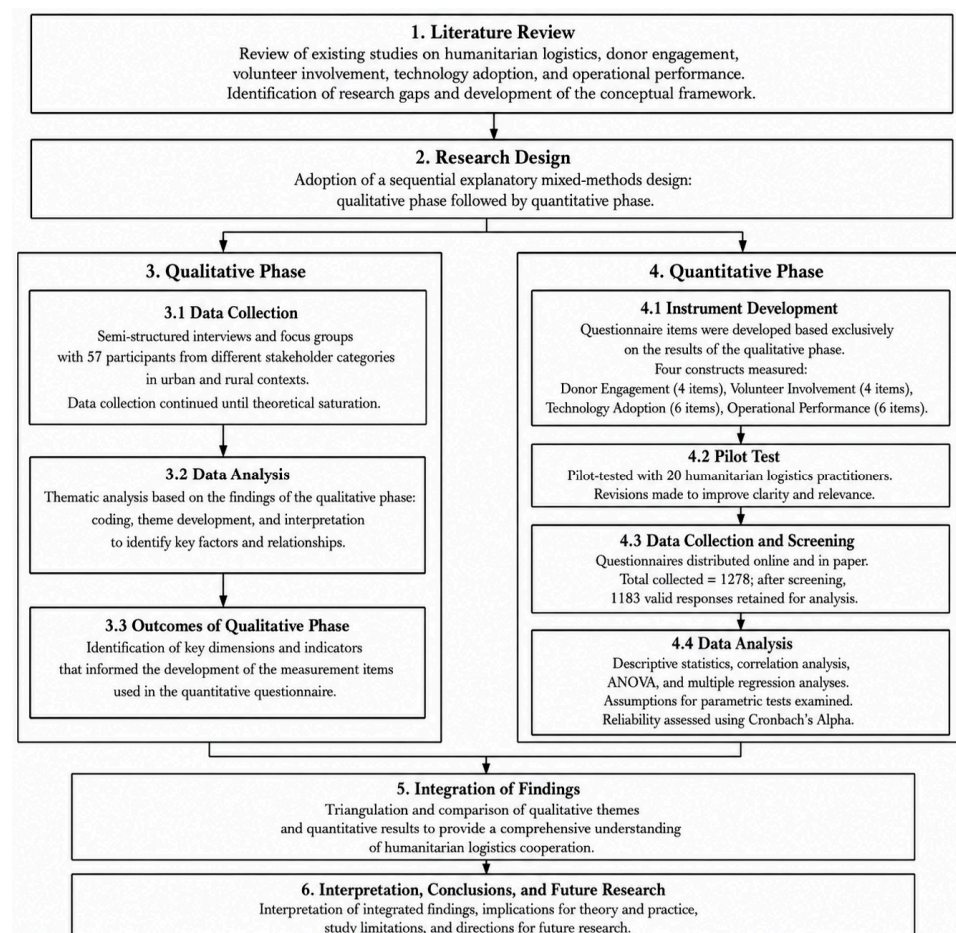


Figure 1. Research process.

## 4. Data Analysis and Results

### 4.1. Qualitative Findings

The qualitative phase involved 57 participants representing urban and rural humanitarian operations, including NGO managers, volunteer coordinators, donor representatives, local authorities, and field volunteers. Their experience ranged from 4.5 to 10.2 years, ensuring insights into both current operational realities and future humanitarian logistics trends

toward 2030. Urban participants emphasized structured coordination, donor oversight, and digital integration, whereas rural participants highlighted adaptive problem-solving, local knowledge, and decentralized practices. Table 2 summarizes the participant profiles.

**Table 2.** Profile of Qualitative Study Participants.

| Participant Type          | Urban Participants | Rural Participants | Total | Average Experience | Main Role/Responsibility                                        |
|---------------------------|--------------------|--------------------|-------|--------------------|-----------------------------------------------------------------|
| NGO Operational Managers  | 10                 | 6                  | 16    | 8.5 years          | Planning, logistics coordination, donor reporting               |
| Volunteer Coordinators    | 8                  | 6                  | 14    | 6.7 years          | Assigning volunteers, supervising deliveries, training          |
| Donor Representatives     | 6                  | 2                  | 8     | 7.3 years          | Funding allocation, oversight, operational guidance             |
| Local Authority Officials | 5                  | 4                  | 9     | 10.2 years         | Regulatory coordination, local resource facilitation            |
| Field Volunteers          | 3                  | 7                  | 10    | 4.5 years          | Last-mile deliveries, community liaison, ad-hoc problem-solving |
| Total                     | 32                 | 25                 | 57    | –                  | –                                                               |

#### 4.1.1. Donor and Volunteer Dynamics

Participants emphasized that donors and volunteers will remain central to Moroccan humanitarian logistics toward 2030, although their roles are expected to evolve considerably. Donors are increasingly perceived as strategic partners supporting predictive systems, volunteer development, and digital coordination tools rather than acting solely as financial contributors. *An urban NGO manager remarked: “By 2030, we expect donors to provide platforms that can anticipate needs and guide delivery planning automatically, while also supporting volunteer training across regions.”* Rural actors nevertheless stressed the need for flexible governance models capable of supporting adaptive field operations. *A rural coordinator explained: “Strict funding rules could hinder our adaptability. For the future, donors must balance accountability with operational flexibility.”* Participants further highlighted the growing role of predictive dashboards and data-driven planning systems. *A donor representative stated: “Our vision for 2030 includes predictive dashboards that show where volunteers and resources are needed most, even before crises occur.”*

Volunteer engagement was similarly identified as a key operational pillar. Urban participants anticipated increasing collaboration between volunteers and AI-assisted coordination systems. *An urban volunteer noted: “By 2030, AI could suggest optimal delivery routes and task assignments, while volunteers make the final decisions on the ground.”* Rural participants emphasized that technology cannot replace local knowledge and community relationships. *A rural volunteer shared: “Even if we get digital tools, understanding local roads, weather patterns, and community needs will still guide our decisions.”* Overall, the findings suggest that humanitarian supply chains will increasingly depend on the integration of technological support with human adaptability and volunteer expertise.

#### 4.1.2. Technology Adoption and Coordination Mechanisms

Technology adoption emerged as a major driver of humanitarian transformation toward 2030. Participants highlighted predictive analytics, AI-supported inventory systems, cloud coordination platforms, and real-time communication tools as mechanisms capable of improving operational visibility and responsiveness. *An urban manager stated: “By 2030, AI could predict supply needs before requests are made, and drones or autonomous vehicles could assist deliveries in complex areas.”* However, rural participants emphasized that infrastructural

limitations and uneven digital access remain significant barriers. *A rural volunteer explained: “Technology will help, but local knowledge and improvisation will remain key to making deliveries work in remote areas.”*

Coordination mechanisms are also expected to become increasingly hybrid and interconnected. Urban participants highlighted centralized dashboards and AI-assisted scheduling systems capable of optimizing operational planning. *An urban coordinator observed: “AI could provide contingency plans and assign volunteers dynamically, but human teams will make final operational decisions.”* Rural actors nevertheless stressed the continuing importance of trust-based and flexible coordination practices. *A rural volunteer noted: “Even in 2030, we will rely on relationships, local knowledge, and flexible planning. Technology is a tool, but humans remain central.”* These findings indicate that future Moroccan humanitarian logistics will likely combine structured digital systems with adaptive and decentralized field coordination.

#### 4.1.3. Resource Allocation and Communication Practices

Resource allocation and communication were repeatedly identified as strategic dimensions shaping future humanitarian supply chains. Participants explained that operational efficiency depends not only on the availability of donor resources, but also on how these resources are distributed and adapted to local operational realities. Urban participants emphasized the growing role of donor-funded inventory systems and predictive allocation tools. *An urban logistics manager explained: “In cities, resources are not only more available, but they are also easier to manage because donors increasingly require structured reporting and digital traceability.”* Participants also highlighted the strategic transition from short-term aid distribution toward long-term capacity-building. *A donor representative stated: “Our future objective is not only to fund supplies, but to invest in local logistics capacity, volunteer training, and decentralized storage.”*

Communication and information sharing were similarly described as critical coordination enablers. Urban actors emphasized the increasing use of digital platforms, messaging systems, and real-time analytics. *An urban coordinator explained: “Today we already rely on digital platforms, but by 2030 these systems will likely integrate real-time analytics and automated alerts.”* Rural participants nevertheless stressed that interpersonal communication and local leadership remain essential when digital systems fail. *A rural volunteer noted: “Sometimes the fastest way to coordinate is still through local leaders or direct contact, especially when technology fails.”* Participants further explained that transparent communication enhances both donor trust and volunteer motivation. *An NGO manager stated: “When volunteers understand how their actions fit into the bigger picture, they feel more committed.”*

#### 4.1.4. Operational Challenges and Best Practices Toward 2030

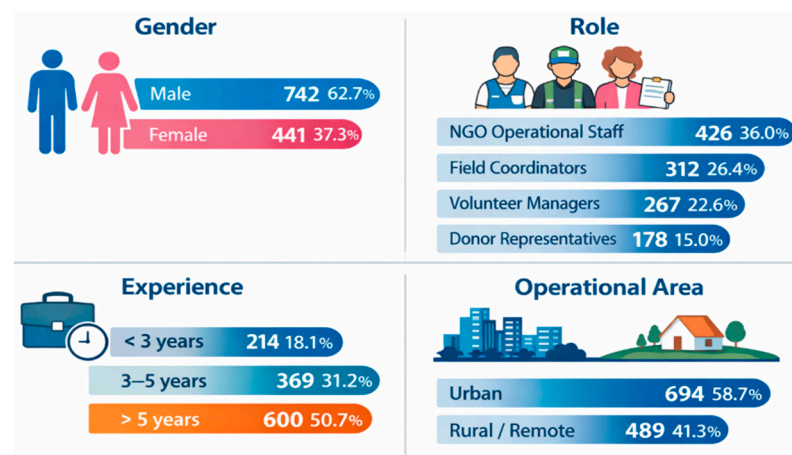
Participants emphasized that operational challenges related to climate risks, infrastructural disparities, and coordination complexity are expected to intensify toward 2030. Rural actors highlighted geographic isolation and environmental uncertainty as persistent barriers to effective humanitarian response. *A rural volunteer explained: “Floods, landslides, or heat waves can block access for days. By 2030, climate issues will probably make this worse.”* Urban participants similarly anticipated increasing coordination difficulties associated with large-scale operations and multi-actor networks. *An urban manager observed: “Even with advanced technology, coordinating hundreds of volunteers and multiple donors will remain complex.”* Participants also stressed the continuing importance of field experience and adaptive learning despite the expansion of digital training systems. *A volunteer coordinator stated: “You can train people online, but real challenges are learned in the field.”*

Regarding future best practices, participants emphasized scenario planning, flexibility, and integrated coordination systems. *An urban NGO manager noted: “Scenario planning helps us prepare for multiple crisis situations, and by 2030 this will be fully supported by predictive tools.”* Rural participants highlighted decentralized adaptability and community engagement as essential resilience mechanisms. *A rural volunteer explained: “We adapt plans daily based on local conditions. This flexibility is our strength.”* Overall, the qualitative findings indicate that future humanitarian logistics in Morocco will increasingly depend on hybrid socio-technical systems integrating donor support, volunteer engagement, adaptive governance, and technology-enabled coordination.

## 4.2. Quantitative Findings

### 4.2.1. Profile of Respondents and Measurement Reliability

The socio-professional profile of the 1183 participants (Figure 2) reveals a diverse and experienced workforce engaged in Moroccan humanitarian logistics. Male respondents constitute 62.7% of the sample, while female participants account for 37.3%, reflecting the sector’s gender distribution. Roles are evenly distributed across NGO operational staff (36%), field coordinators (26.4%), volunteer managers (22.6%), and donor representatives (15%). More than half of respondents report over five years of experience, indicating that the sample is highly informed about historical practices, operational challenges, and emerging trends. Urban operational areas dominate slightly (58.7%), but rural and remote areas are well represented (41.3%), ensuring that the study captures contextual variability in infrastructure, communication networks, and resource availability. This diversity is critical for understanding cooperation dynamics, as urban environments typically feature structured donor oversight and technology-supported coordination, whereas rural settings rely heavily on volunteer mediation and adaptive practices.



**Figure 2.** Socio-professional profile of respondents.

Reliability analysis (Table 3) confirms that all constructs, summarized in Table 1, exhibit high internal consistency, with Cronbach’s alpha values exceeding 0.85. The operational performance scale, in particular, demonstrates strong coherence, suggesting that respondents consistently evaluate delivery timeliness, coordination efficiency, responsiveness, and resource utilization as interconnected components of humanitarian performance. These results validate the measurement instruments and justify the use of composite indices in subsequent correlation, ANOVA, and regression analyses. The reliability supports confidence in interpreting the quantitative relationships between donor engagement, volunteer involvement, technology adoption, and operational performance.

**Table 3.** Reliability analysis of measurement scales.

| Construct               | Number of Items | Cronbach's Alpha |
|-------------------------|-----------------|------------------|
| Donor engagement        | 4               | 0.871            |
| Volunteer involvement   | 4               | 0.883            |
| Technology adoption     | 6               | 0.856            |
| Operational performance | 8               | 0.902            |

#### 4.2.2. Donor Engagement and Operational Performance

Descriptive statistics (Table 4) indicate that Moroccan humanitarian organizations experience high levels of donor interaction, particularly in communication frequency and reporting requirements. Donor influence on operational planning also scores relatively high, suggesting that donors participate actively in shaping logistical decisions rather than serving as passive funders. Funding flexibility, however, is comparatively lower, highlighting a structural tension: while donors enable operational capacity through structured financial support and oversight, excessive rigidity may constrain adaptive responses to dynamic crises. These findings align with qualitative insights indicating that donor involvement simultaneously empowers and restricts operational decision-making, a duality that is expected to become more pronounced as digital monitoring and predictive dashboards gain prominence by 2030.

**Table 4.** Descriptive statistics—Donor engagement variables.

| Item                                    | Mean | Std. Dev. |
|-----------------------------------------|------|-----------|
| Frequency of donor communication        | 4.12 | 0.73      |
| Donor influence on operational planning | 3.89 | 0.81      |
| Donor requirements for reporting        | 4.35 | 0.65      |
| Flexibility of donor funding            | 3.41 | 0.92      |

The one-way ANOVA analysis (Table 5) indicates that differences in donor engagement are significantly associated with delivery timeliness. Organizations with higher engagement levels perform better operationally, emphasizing the importance of structured donor participation in achieving efficient supply chain outcomes. However, excessive oversight can create tension in highly dynamic contexts, particularly in rural areas where rapid decision-making is critical. These results underscore the need for adaptive donor models that integrate accountability with operational flexibility, a requirement that will likely intensify as humanitarian logistics becomes increasingly digitized by 2030.

**Table 5.** One-way ANOVA—Donor engagement level and delivery timeliness.

| Source         | Sum of Squares | df   | Mean Square | F    | Sig.  |
|----------------|----------------|------|-------------|------|-------|
| Between groups | 42.18          | 2    | 21.09       | 9.74 | 0.000 |
| Within groups  | 2553.44        | 1180 | 2.16        |      |       |
| Total          | 2595.62        | 1182 |             |      |       |

#### 4.2.3. Volunteer Involvement and Coordination Efficiency

Descriptive data (Table 6) illustrate that volunteer engagement is critical for coordination, particularly when volunteers receive adequate training. Mean scores suggest that volunteer effectiveness is high, yet coordination challenges persist, highlighting the hybrid nature of Moroccan humanitarian operations that rely on both professionals and volunteers

of varying experience. These findings support the qualitative insights suggesting that volunteer engagement is associated with stronger operational performance when embedded within structured management frameworks.

**Table 6.** Descriptive statistics—Volunteer involvement.

| Variable                              | Mean | Std. Dev. |
|---------------------------------------|------|-----------|
| Adequacy of volunteer training        | 3.58 | 0.91      |
| Volunteer effectiveness in operations | 3.76 | 0.84      |
| Coordination challenges               | 3.21 | 0.96      |
| Retention of skilled volunteers       | 3.44 | 0.88      |

The ANOVA results (Table 7) indicate that training level significantly affects coordination efficiency. Organizations providing structured training report fewer failures, reinforcing the importance of semi-professionalized volunteer management. As humanitarian logistics systems evolve toward 2030, volunteers are expected to increasingly interact with digital platforms and predictive tools, making training a cornerstone for maintaining reliability and integrating human actors into technologically mediated supply chains.

**Table 7.** One-way ANOVA—Volunteer training and coordination efficiency.

| Source         | Sum of Squares | df   | Mean Square | F     | Sig.  |
|----------------|----------------|------|-------------|-------|-------|
| Between groups | 58.74          | 2    | 29.37       | 13.62 | 0.000 |
| Within groups  | 2541.09        | 1180 | 2.15        |       |       |
| Total          | 2599.83        | 1182 |             |       |       |

#### 4.2.4. Technology Adoption as a Coordination Amplifier

Table 8 shows that while basic tools such as inventory tracking and routing software are widely used, AI-based decision-support tools remain less prevalent. This adoption pattern reflects a transitional phase in Moroccan humanitarian organizations, constrained by infrastructure, cost, and skills, yet moving toward digital integration. Pearson correlations (Table 9) confirm strong, positive relationships among donor engagement, volunteer involvement, technology adoption, and operational performance. Technology adoption emerges as a critical amplifier of human coordination rather than a substitute, enabling greater efficiency, visibility, and responsiveness.

**Table 8.** Technology adoption levels.

| Technology                              | Mean Usage |
|-----------------------------------------|------------|
| Inventory tracking systems              | 4.01       |
| Routing and transport planning software | 3.74       |
| AI-based decision-support tools         | 3.12       |

**Table 9.** Pearson correlation matrix.

| Variable                | Donor Eng. | Volunteer Inv. | Tech Adoption | Operational Perf |
|-------------------------|------------|----------------|---------------|------------------|
| Donor engagement        | 1          |                |               |                  |
| Volunteer involvement   | 0.46 **    | 1              |               |                  |
| Technology adoption     | 0.52 **    | 0.49 **        | 1             |                  |
| Operational performance | 0.58 **    | 0.54 **        | 0.63 **       | 1                |

(\*\*  $p < 0.01$ ).

#### 4.2.5. Predictive Analysis—Joint Effects on Performance

Regression results (Table 10) reveal that donor engagement, volunteer involvement, and technology adoption collectively explain 56% of operational performance variance. Technology adoption is the strongest predictor, yet donor and volunteer variables remain statistically significant, demonstrating that effective humanitarian supply chains emerge from integrated human–digital cooperation. These results suggest that operational performance toward 2030 may increasingly depend on the convergence of financial governance, human coordination, and technological infrastructure.

**Table 10.** Multiple regression analysis—Predictors of operational performance.

| Predictor             | $\beta$ | t     | Sig.  |
|-----------------------|---------|-------|-------|
| Donor engagement      | 0.31    | 8.12  | 0.000 |
| Volunteer involvement | 0.27    | 7.45  | 0.000 |
| Technology adoption   | 0.39    | 10.66 | 0.000 |
| R <sup>2</sup>        | 0.56    |       |       |

The integration of these findings suggests that technology, donors, and volunteers may interact synergistically in shaping humanitarian logistics performance. Isolated interventions are insufficient; organizations must design coordinated, socio-technical systems that balance oversight, human capacity, and digital facilitation. The results support and extend the qualitative insights, suggesting that the future of Moroccan humanitarian logistics is likely to involve increasingly cooperative and digitally mediated networks, positioning human–technology convergence as an important factor associated with operational efficiency by 2030.

## 5. Discussion

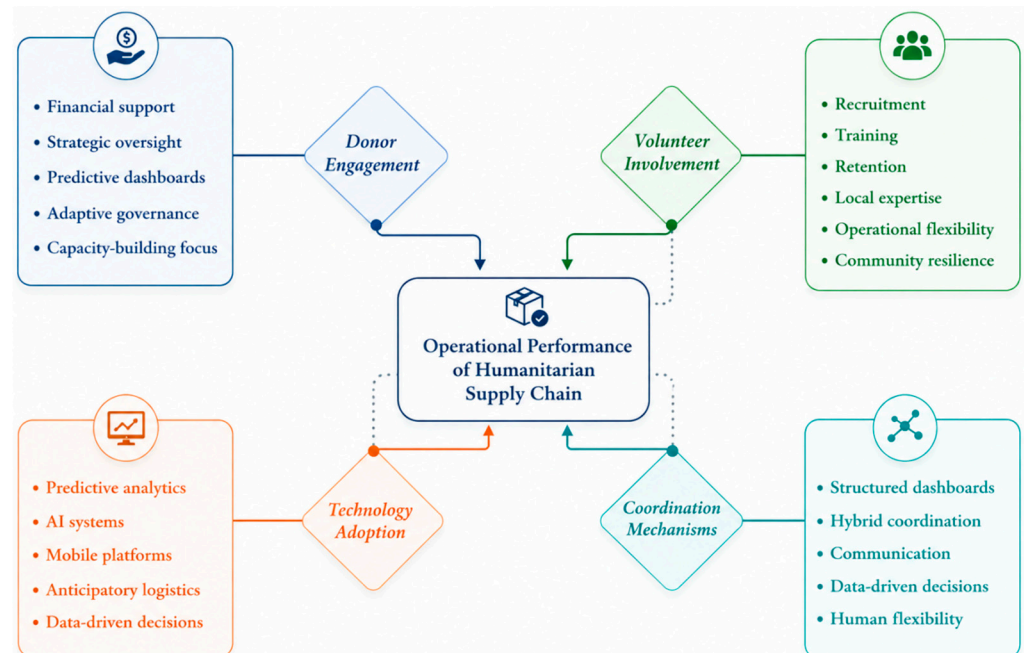
The findings suggest that the future of humanitarian logistics in Morocco may increasingly depend on the integrated interaction between donors, volunteers, and digital technologies within adaptive socio-technical supply chain systems. Quantitative and qualitative results confirm that donor engagement, volunteer involvement, and technology adoption jointly enhance operational performance and coordination efficiency, explaining a significant share of performance variance. This indicates that humanitarian effectiveness cannot be achieved through isolated interventions, but requires coordinated multi-actor systems combining financial governance, human capacity, and digital infrastructure. These results align with previous studies on collaborative humanitarian coordination [12,13,17] while extending them by showing their simultaneous interaction within a unified framework.

Donors are increasingly evolving from funding providers into strategic partners supporting innovation, capacity building, and predictive planning, consistent with [27]. Meanwhile, volunteers remain essential, particularly in rural contexts where local knowledge and adaptability compensate for infrastructure gaps. In line with [30,32], their effectiveness depends on coordination, communication, and contextual flexibility. Although digital technologies improve visibility and efficiency, the results confirm that they complement rather than replace human decision-making.

The Moroccan context highlights the need for hybrid coordination systems combining structured urban models with flexible rural practices. Urban operations rely on data-driven planning and centralized coordination, while rural operations depend on interpersonal communication and adaptive decision-making. These findings support [18,20], emphasizing trust, communication, and knowledge sharing as key drivers of efficiency. However,

growing climate risks, infrastructural disparities, and coordination challenges are expected to intensify toward 2030.

Overall, the proposed framework (Figure 3) illustrates that humanitarian logistics performance emerges from the synergy between donors, volunteers, and technology. It positions socio-technical integration as a central mechanism associated with resilience, adaptability, and sustainability in Moroccan humanitarian supply chains toward 2030.



**Figure 3.** Conceptual model.

### 5.1. Implications for Theory

This study contributes to humanitarian logistics theory by proposing an integrated socio-technical perspective explaining how donors, volunteers and digital technologies collectively shape supply chain cooperation and operational performance. Unlike previous studies that examined financial resources, volunteer engagement or technology adoption separately, this research demonstrates that humanitarian supply chain resilience depends on the interaction between these dimensions within a unified collaborative framework. The findings therefore extend network-based and relational coordination perspectives within humanitarian logistics literature.

The study also contributes to research on humanitarian supply chains in emerging economies by emphasizing the importance of contextual factors such as geographical diversity, infrastructural disparities and community-based coordination mechanisms. Consistent with previous studies on relational coordination and adaptive governance, the findings indicate that technological innovation alone may not guarantee operational efficiency unless supported by trust, communication and locally embedded human capabilities. Furthermore, by adopting a forward-looking perspective toward 2030, the study contributes to the growing literature on future-oriented humanitarian logistics and digitally mediated cooperation systems.

### 5.2. Implications for Practice and Policy

The findings provide several practical implications for humanitarian organisations, policymakers and donor institutions. First, humanitarian organisations should adopt integrated coordination models combining predictive technologies, AI-supported planning systems and digital communication tools with human-centered operational practices. Con-

tinuous volunteer training, decentralized coordination and adaptive resource allocation mechanisms remain essential, particularly in rural and remote areas.

Second, donor institutions should move beyond short-term funding approaches and invest in long-term logistics capacity, volunteer development and digital infrastructure. In line with the findings, flexible donor governance models are necessary to balance accountability requirements with operational adaptability during rapidly evolving crises. Recent reductions in international humanitarian funding, including budget constraints affecting major donor institutions such as USAID, may create additional challenges for humanitarian supply chains in the coming years. Such developments highlight the importance of diversifying funding sources, strengthening local partnerships, and improving resource utilization through digital technologies and collaborative coordination mechanisms. In this context, humanitarian organisations may need to become increasingly resilient and adaptive in order to maintain operational effectiveness despite potential funding uncertainties.

Third, policymakers should strengthen infrastructure development and digital accessibility in underserved regions while promoting standardized communication and data-sharing systems between governmental agencies, NGOs, donors and volunteer networks. Finally, the findings highlight the strategic importance of communication, trust-building and collaborative planning within humanitarian supply chains. Transparent information-sharing systems and coordinated operational frameworks can strengthen donor confidence, volunteer engagement and inter-organisational cooperation, thereby improving humanitarian responsiveness and resilience toward 2030.

### *5.3. Limitations of the Study and Future Research Directions*

Despite its contributions, this study presents several limitations. First, the research focuses exclusively on Morocco, which may limit the generalisability of the findings to other humanitarian contexts with different institutional or infrastructural conditions. Second, the study adopts a cross-sectional design based on current perceptions and future projections toward 2030 rather than longitudinal observation of humanitarian logistics evolution. Third, although the mixed-method approach strengthens analytical depth, the quantitative data rely partly on self-reported measures that may contain subjective bias.

Future research could conduct comparative studies across North African, Sub-Saharan African, European, Asian, and Latin American humanitarian contexts in order to examine how institutional, technological, and socio-cultural factors influence supply chain cooperation. Longitudinal studies would provide valuable insights into the evolution of donor strategies, volunteer engagement, and technology adoption over time. Additional research may also investigate emerging technologies such as blockchain systems, autonomous delivery solutions, AI-driven crisis prediction tools, and digital humanitarian ecosystems. Furthermore, future studies could explore the implications of changing international funding structures, including shifts in donor priorities and reductions in humanitarian aid budgets, on supply chain resilience and operational effectiveness.

## **6. Conclusions**

This study examined how humanitarian logistics in Morocco may evolve toward 2030 by analysing the combined roles of donors, volunteers, and digital technologies in strengthening supply chain cooperation and operational resilience. Using a mixed-methods approach, the findings indicate that donor engagement, volunteer involvement, and technology adoption are positively associated with coordination efficiency, responsiveness, and operational performance. The results show that donors are increasingly evolving from traditional funding providers into strategic partners supporting digital infrastructure,

predictive planning, and volunteer capacity-building, while volunteers remain essential for adaptive and community-based operations, particularly in rural and mountainous areas.

The study further indicates that technologies such as AI-supported coordination systems, predictive analytics, and digital communication platforms may enhance visibility and resource allocation when integrated into human-centered governance systems. However, the findings suggest that technology alone may not ensure effective humanitarian logistics. Rather, resilient supply chains are more likely to emerge from hybrid socio-technical systems combining digital innovation with human expertise, local knowledge, and collaborative decision-making. The conceptual framework proposed illustrates these interconnected relationships and highlights how donor engagement, volunteer coordination, and technological integration jointly shape humanitarian supply chain resilience toward 2030.

The Moroccan context also emphasizes the importance of balancing structured urban coordination mechanisms with flexible rural practices. Communication, trust-building, adaptive resource allocation, and decentralized coordination therefore remain critical for improving cooperation and long-term resilience. The study contributes to humanitarian logistics literature by proposing an integrated socio-technical perspective that combines financial governance, volunteer coordination, and technology adoption within a unified framework.

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