Skill Mismatch and Reskilling Pathways for Fisheries Workers in Developing Countries under Digital Transformation

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Abstract. The major part of the research focus is the demand-supply incongruity experienced by the labor market of fisheries in the developing nations during the era of digital transition. They have up to now been relying on time-consuming manual operations done by low-skilled labor. Now, owing to the digitalization of the industry, waves of attractive technologies such as blockchain, smart sensors, mobile payments, and e-commerce are being adopted. Moreover, the process leads to enhancement of efficiency. On the other hand, those workers who lack digital skills are in a job insecurity group, and it looks as though they are falling into the digital poverty background. Cases in Indonesia, the Philippines, Nigeria, and Bangladesh show the growing digital reliance. However, the pandemic is the continuing factor for its uneven responses in many areas of the world. Skill gaps endure in the areas of documenting, tracing, cold chain logistics, and information technology, and at the same time, the requirements for building capacities involve blockchain, cloud computation, and mobile reporters. Governments, private companies, and international organizations need to join forces to launch inclusive retraining programs, provide mobile-based learning, and offer gender-sensitive tutoring services if they want to deal effectively with the problem. Fisheries digitation does not only imply advanced technology selling, but also socially and institutionally reforming. Bridging the digital gap entails a variety of solutions, which should be continued, localized, and inclusive, with the aim of reaching marginalized groups, women, older workers, and migrants.

Keywords: Digital Transformation, Fisheries Sector, Gender Equity.

1 Introduction

Digital technologies under the Fourth Industrial Revolution are altering industrial underpinnings on a global scale [1]. In the world's poorer nations, this digitalization process also has an impact on the fisheries sector, which, up to now, has been considered a conventional, labor-intensive industry [2]. The sector's transition from manual operation and analog trade to digitally controlled and technology-assisted management can be attributed to the smart logistics, blockchain-based traceability, digital payment systems, and e-commerce platforms available [3,4]. The disruption alongside the

J. Rak et al. (eds.), *Proceedings of the 2025 4th International Conference on Educational Science and Social Culture (ESSC 2025)*, Advances in Social Science, Education and Humanities Research 1004,
https://doi.org/10.2991/978-2-38476-553-9_38

technology route, however, entails both efficiency gains and trade-offs, especially for low-skill laborers at the base of the food supply chain [5,6].

The majority of workers who are involved in fisheries employment in various developing countries are either highly uneducated or lack essential technical skills. These industrial workers often depend on strenuous jobs and do not have any provision for digital training or vocational education opportunities. As the pace of digitalization is built up, there is a significant degree of skills mismatch in the sector: the newly created occupations—like digital inventory monitoring, smart cold chain management, and automated machine operation—call for abilities that the workforce does not even possess in most instances [7,8]. Failure to provide such programs as reskilling and upskilling may contribute to a high level of job insecurity, greater digital inequality, and more cases of social marginalization [9,10].

Owing to these diversions, institutions such as the Food and Agriculture Organization (FAO) and the International Labour Organization (ILO) have already started to urge companies and nations to develop digital adaptation strategies in a more inclusive manner [2,6]. They stress that issue of skills development and reskilling for all displaced workers. Although an increasing amount of literature has been devoted to the study and understanding of how digitalization impacts labor in agriculture and manufacturing, fisheries (identified as informal, seasonal, and comprising a large number of female workers) remain a substantially under-researched area [11,12]. In several developing nations, fisheries are the predominant source of employment, with coastal and rural communities being the most affected. The case studies of countries like Bangladesh, Indonesia, Nigeria, and the Philippines are useful because they are all dependent on small-scale fisheries, many workers still operate in the informal economy, and the governments are trying to introduce digital technologies into fisheries management [12,13]. These countries also believe to be the most affected in terms of education infrastructure, digital literacy, and gender equity in the fisheries sector, representing the trends of the whole Global South [14-16].

Furthermore, their policy responses to digital transformation are heterogeneous and exhibit varying levels of success, thus allowing for the comparative assessment of the impact of reskilling initiatives. What the catch documentation system embarked on by Indonesia, the e-logbook, shows is that, on one hand, the industry's digital integration is still in the early stages of the process [12]. While on the other hand, the Smart Fish project of Nigeria only shows how donors endeavor to put technology into use with the greater effectiveness of the labor force [13]. The thing that jumps out is that the emphasis on an overall integration plan of innovation, which has inclusivity and skills development concerns integrated, is absent.

To ensure digitalization of mature industries, for example, fisheries, invested in reskilling pathways should be appropriate to the challenges that the localities experience, i.e. internet access and infrastructure issues, as well as language barriers and lack of governmental support. Then, economic viability is not enough to get to such a point where an economy can function, but the added dimension is the skill gap and the digital gap - these two points are the main foundation of this thesis [14].

In this research study, specifically those strategies will be proposed that have the potential to eliminate labor issues confronting low-skilled fisheries workers in

developing nations during digital transition. The project will define not only the type of skills that are lacking, but also the range of them and will examine individualized reskilling pathways that support inclusive transitions. This study will, through the examination of the policies for fisheries in national contexts, the statistic of labor markets of the country, and the observation of new digital techniques in use, aspire to provide practical solutions to the questions of which skill gap should be dealt with in the fisheries industry. Furthermore, it targets casting no worker adrift in the present and future century of digitalization.

2 Literature Review

2.1 Digital Transformation and the Fourth Industrial Revolution

The technologies of digital transformation in the Fourth Industrial Revolution, such as artificial intelligence (AI), blockchain, Internet of Things (IoT) and cloud computing, are implemented in a way that erases the divisions among the physical, digital and natural borders [1]. The effect of the digital revolution in developing countries is seen not simultaneously but in a staggered way, as the change still fails to reach the freely informal and unemployable capital-sharing fisheries [5]. The ways by which fisheries employ digital technologies encompass smart sensors for catch monitoring, mobile access platforms, and satellite-based tracking of vessels [7,8]. In addition, possible digital innovations will give guarantees of efficiency and transparency [15]. On the flip side though, they will require the new-age workforce that is digitally literate and techno-savvy, which is extremely rare in the present-day demographics [10].

2.2 Skill Mismatch in Traditional Sectors

Worker skill mismatch is the phenomenon in which the talent pool and the competencies needed in the job market do not coincide [6]. The issue of formal education and training infrastructure is particularly serious in the case of agriculture and fisheries, as the rates of formal education are low and the sources to build up the training infrastructure are also low [11]. Out of leftover generations, only the traditional manual practices are observed to continue. McKinsey Global Institute estimates suggest that more than one-tenth of the global labor force in 2030 will be made up of job seekers who are obliged to switch sectors [5]. In fishing, the majority of occupations that used to require merely physical stamina now have a digital component in the form of GPS mapping, inventory software, and online payment systems [7]. This mismatch leads to the gap in foothold – demand-supply mismatch of the labor market in the areas mainly of developed countries [16].

2.3 Reskilling and Upskilling Frameworks in Global Development

In international discussions, the importance of reskilling and upskilling for developing countries has been a central theme: baffling as it may be, the digital transformation

could paradoxically increase the unemployment rate among the vulnerable populations [5]. In other words, reskilling refers to what it is – training people for a different job; meanwhile, upskilling implies the enhancement of skills to work more efficiently and with a possibility for promotion within the same job area. Governments, as well as international organizations, have developed different guides, plans, and frameworks for monitoring that are meant to promote lifelong learning [9]. These include the ILO's Skills for Employment Policy guide and the UNESCO's benchmarks for digital literacy. In many of the best practices or models, the key components are public-private partnerships, mobile learning platforms, and community-based vocational centers [12]. On the other hand, these approaches so far have not appeared to be especially attractive, and also, they are not scalable geographically, which prevents a majority of future workers ready to work in the digital environment.

2.4 Digitalization in Fisheries: A Neglected Agenda

Although there is much literature on digitalization in the agricultural and manufacturing sectors, the fisheries industry, particularly in less-developed countries, remains not only understudied but also unexplored with respect to the level of digital readiness and the use of technology by labor forces [2,6]. This ignorance can be attributed to the fact that fishery employment usually takes an informal, seasonal, and gender-biased type, where the majority of the workforce comprises women or migrants with little formal education and almost no access to technical training [11]. Consequently, the labor force becomes acutely exposed to the dangers of technological exclusion and displacement, which may occur as a result of using automated solutions such as blockchain for traceability and AI systems for inventory that will be implemented to establish the industry standard.

Research indicates that digitalization in the fisheries sector, such as fishing logistics supported by satellite tracking, e-commerce, and smart logistics, are some of the innovations that help in building transparent and efficient markets [7,8]. However, these benefits alone do not ensure an equitable market; otherwise, it may result in the further widening of the financial gap in coastal societies if the proper reskilling is not done [11]. In fact, the strategies of digital development with an inclusive approach are gaining more attention; this is because such a strategy should encompass proper reskilling and capacity building alongside the provision of social protection to workers displaced by the blue economy.

Moreover, it should be noted that the fisheries sector is especially exposed not only to climate change but also to other environmental disturbances, and they are the major factors that affect labor transformation. Therefore, to achieve successful interventions, all circumstances, cultural aspects, as well as ecological limits of marine systems, should be encompassed as a crucial part of scalable skill development programs [17, 18]. Thus, the present research ought to address and edify the gap in knowledge by suggesting specific retraining paths that are based on international best practices as both policy and science professional edition.

3 Findings and Analysis

3.1 Existing Skill Gaps in Fisheries Workforce

The workforce in fisheries during the times of developing countries mostly consists of individuals with no exposure to technology and who do not have advanced formal education. Most workers are usually in the informal sector, a situation where they engage in hard physical tasks without structured training or upskilling pathways. Consequently, there are evident deficiencies in technical work, digital capability, and other skills to learn new technologies [6].

Particular gaps in skills include not knowing digital record-keeping systems, not understanding the use of tools for traceability, not having experience with cold chain technologies, and not being familiar with using mobile communication devices [7]. Moreover, many older workers and women in rural areas may also be found in such communities due to various gender roles, language barriers, and a lack of academic resources [16].

3.2 Emerging Digital Competencies in the Sector

Digital transformation, being the driver of change in the sector, is causing new competencies to emerge and be in demand for participation and inclusion in the workers. Therein lies the capacity to control smart factoring systems, use satellite-based monitoring tools, and participate in mobile payments [4].

Added to that, skills on data entry, knowledge on how to use blockchain-based tools for traceability, and basic IT troubleshooting are also becoming pivotal to guarantee compliance and efficiency [8]. In industries previously relying on manual jobs or seasonal positions, there is a suddenly growing expectation that workers will be able to interface with cloud-based management systems, creating the urgency for upskilling [7].

3.3 Inclusive Reskilling Pathways: Global and Local Case Studies

The path to fisheries sector's inclusive upskilling approach should be firstly local in style, which contemplates the use of both international standards and native implementation platforms [9]. As a result, players like Indonesia, the Philippines, and Nigeria tell different stories. For example, Indonesia has a digital platform for information about the catch, such as e-logbooks where this information is uploaded, meaning that fishers are now doing traceability with ease and efficiency by using the digital platform and training conducted by Smart Fish in Nigeria [12,13].

They indeed show that designing programs with the many conditions of the informal markets in mind, one of the biggest things to get right is that these programs have to be user-friendly [6]. Instilling such a hub culture at the grounds near training centers, together with mobile schools, which will be used to visit different areas, and working with farmer cooperatives, and the like, will help the general public to participate easier and to build trust [5]. Furthermore, integrating women-friendly actions that give

women's agency in the coastal regions into digital transformation expedite the sustainability and equity of the process [11].

The obstructions to the access of technology, poor infrastructure, and literacy can be resolved through the application of innovative, scalable, participatory, and culture-friendly methods. These methods prioritize the practical building of skills, need for access to technology, and ownership at the level of the community to unfold fuller impact [18].

3.4 Comparative Study of Digital Readiness of Developing Nations' Fisheries

Although the fishery digital transformation readiness index scores are similar across developing nations, their readiness for digital transformation to reach a new level differs considerably. Indonesia and the Philippines, both countries with numerous islands throughout their territories, are at the forefront of fishery digital transformation due to their greater digital infrastructure and availability of international donors compared to many other developing countries [12,13]. For instance, in Nigeria, fishers are constrained by infrastructural problems such as irregular electricity supplies and low internet use along the coasts, what makes basic mobile access impossible for their activities [2].

Bangladesh, the third "chronic inshore fishery job" country indexed by NGOs, suffers from over-dependence in the training issue that results in disseminated, piecemeal interventions [6]. The digital divide truly is a dichotomy. First of all, digital connections have the possibility to tear down walls, however, using technology as the prime mundane in the workplace results in a new degree of inequality [16]. For instance, there are some regions, like Nigeria, where women largely work in the informal fisheries sector. In those places, along with the technology barriers and the language barriers, these are the critical factors for the programs to be successful [11].

Furthermore, various countries in Latin America, such as Peru, are exploring open-data fisheries systems and using SMS-based traceability itineraries for the isolated communities, and those types of itineraries may work to narrow the digital gap as they are inexpensive but inclusive [14]. Consequently, it is certain that the fact of the multiplicity of methods shows that there is no universal reality. Hence, policies have to be dynamic, otherwise the content has to fit the local environment, economic constraints, and the lifestyle [9].

4 Policy Recommendations

4.1 Role of Government and International Organizations

The governments of developing countries have the opportunity to spearhead the creation and implementation of digital transition plans. These plans should ideally reflect the views of marginalized communities, particularly those in the fisheries sector [9]. National policies must articulate well-defined milestones for the advancement of digital know-how among coastal communities and the rural populace, and ensure the delivery

of relevant training programs that are culturally and linguistically suitable [11]. Through the conceptualization of digital transition as a vertical integration with the establishment of specialized agencies within the political ministries of agriculture or labor, the incorporation of cross-sector cooperation for such transition becomes feasible [4].

The governments may resort to international organizations such as FAO, ILO, and UNESCO for funding, policymaking materials, and professional advice [2,6,10]. South-South cooperation networks supported by universal platforms can facilitate this, and as a bonus, it can be very simple to spread best practices and successful solutions [3]. As a case in point, the implementation of digital traceability can come in with FAO's help, while the facilitation of transition programs can be done by ILO through the provision of the handbook for expertise [2,6].

4.2 Designing Inclusive Reskilling Programs

The reskilling techniques should use socioeconomic differentiation of fishery workers as the main characteristic. Women, older workers, and migrants should be focus on explicitly without their exclusion. Curricular development has to center upon practical digital competencies of mobile-based reporting tools usage, providing understanding of blockchain traceability, and operating automated fish processing equipment [4,9].

Referring to the provision of accessibility, the training should be delivered hybrid, i.e., through mobile phone applications, radio, and in-person workshops. They must also consider the seasonality, hence offering flexible scheduling, and further incentivizing participation through micro-credential and digital badges that present value proposition linked to employability in digital labor markets [7,16].

4.3 Public-Private Partnership Models

The public-private partnership (PPP), where all the participants in the reskilling process should be included, is paramount for the sustainability and scalability of the programs. Governments can collaborate with technology companies, logistics platforms, digitalized commerce platforms, and add knowledge about the practical apprenticeships on these issues. In this regard, the role of fintech companies to provide the fishery workers with knowledge about the use of digital payment solutions, and that of the logistics firms to offer training in cold chain management technologies, cannot be overemphasized [3,13,14].

Besides, setting up digital innovation centers or community centers in fishing hubs may enable them to access technology and mentorship right at the doorstep. The innovations incubated there will help all the stakeholders in race-to-market effort, as the iterative adjustment will be based on real-time end-user feedback. Private sector players gain from such partnerships as they get faster access to a digitally savvy and more competent workforce [14].

4.4 Integrated Policy Pathways for Sustainable Upskilling

Identifying policy tracks, such as labor force transformation, education policy, and digital innovation, merging them will be the basis of digital inclusiveness and sustainability. Policies can be designed through several measures. First, creating National Fisheries Digital Roadmaps should be prioritized by countries, which will consist of clearly stated timeframes, targeted groups among youth and women, and earmarked funding to implement steps aimed at enhancing digital capacity [15,16]. These roadmaps should integrate the broader digital economy objectives as well as UN Sustainable Development Goal 14 that concerns Life Below Water. Second, cooperation across minies such as education, labor, fisheries, and ICT, and also sharing information with each other concerning the inclusion of digital literacy into TVET - Technical and Vocational Education and Training systems within the blue economy, are important for this purpose [10]. Therefore, the co-design process with fishing unions and scientific bodies is beneficial to the training programs, which ultimately enables the creation of regionally relevant training modules, i.e., using local languages and considering gender roles and cultural traditions in fisheries [14,16].

By moving beyond just program design, which includes a key role in community monitoring processes in ensuring accountability and adaptability, it is possible to achieve more resounding results. Digital dashboards, as well as community committees, can monitor those initiatives' progress and offer feedback loops for daily operations improvement in the reskilling process [8,18]. By going beyond the technological side and involving all stakeholders, such as the local communities, the industry players, and the government, the fisheries sector can experience a digital transition that is both sustainable and equitable.

5 Conclusion

This study was conducted to understand the skill mismatch problem and the possible reskilling opportunities that could be implemented for fisheries workers in developing countries during the age of digital transformation. In their research, the authors show that digital technologies such as blockchain, smart sensors, and mobile platforms are being increasingly used throughout the fisheries supply chain. Digitalization brings about several benefits, but the workforce, which is mainly informal, low-skilled, and under-educated, encounters numerous obstacles to transition because they lack digital literacy, training opportunities, and gender- and age-inclusive centers of learning.

Cross-country comparative case studies conducted in Indonesia, the Philippines, Nigeria, and Bangladesh, demonstrated that although digital adoption is steadily growing, the frameworks for reskilling are still underdeveloped and inconsistent among countries. A few nations could show the way with pilot projects and donor-funded initiatives. Nevertheless, there is no existence of scalable, inclusive, and sustainable interventions that would reach marginalized people.

Besides that, the studies suggest that successful digitalization in the fishing industry is not only a question of technology but social and institutional aspects as well. Providing methods to bridge the digital gap is a task that needs approaches that are sensitive

to the context and take into account such elements as participatory training design, public-private partnerships, and proactive government coordination. The article stresses that the task of reskilling needs to be a systematic endeavor, not just a quick fix here and now. It should be part of longer-term development strategies that take seasonal employment, informal work, and regional income gaps into account.

Whereas this study provides vital insights, there are some constraints as well that can be considered. First, since time and data limitations are the major causes, the analysis primarily uses secondary sources and available case reports. It will be useful to conduct field-based empirical research that includes conversations with fishery workers, trainers, and local government officials, which will add to the analysis and give it a deeper contextual dimension.

Second, the study perimeter mainly embraces small-scale fishing, while the other segments of fishing businesses such as processing, trading, and transportation, which are also affected by the digital transformation, are outside the consideration. Future research should ideally cover the whole fisheries ecosystem to account for the various skill demands and appreciate the complex web of echo-system-wide interdependencies.

Third, the dimension of gender and youth in the fishing workforce remains mentioned rather than thoroughly studied. As women and the youth are underrepresented in low-skilled and informal positions, which are usually the least desirable, there is a need for future studies to look at specific interventions that target these groups and evaluate the long-term impact of such on labor equity and digital inclusion.

No less importantly, the efficacy of certain formal training tools, such as mobile learning, peer-to-peer knowledge sharing, and gamified learning, within low-resource and low-literacy zones, remains insufficiently studied. Future research should target identifying the optimum use of these tools for adult learners in fishing communities that will lead to higher learning results and employment opportunities.

As a final point, the research adds to the ongoing discussion about the digital inclusion and labor transformation of the Global South by exposing the necessity for united, fair, and local-oriented policies. It calls upon the coordinated intervention, with popular backing, of governments, civil societies, and private-sector actors. In this way, every fishery worker would be guaranteed the right to participate in the digital era.

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