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Local Artisans' Knowledge of Flood Resilient Construction and Adaptation of Residential Buildings in Flood-Prone Informal Settlements in Dar es Salaam, Tanzania

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ABSTRACT: Flood-prone informal settlements are among the most complex and challenging construction sites that require adequate knowledge to enhance flood resilience and adaptation. While such settlements present construction challenges that need the attention of professionals, anecdotal observations and experiences in developing countries and Tanzania, in particular, indicate a vast preference to engage and prioritise local artisans in such areas under the pretext of the high cost of affording professionals. This article sought to understand how the local artisans were knowledgeable of construction of residential buildings in flood-prone informal settlements in Dar es Salaam. To understand this phenomenon, various flood-resilient and adaptive measures that local artisans presumed to be aware of and which they were using in constructing buildings in flood-prone areas were analysed. The article adopted a case study design where qualitative data were collected using key informant interviews and focus-group discussions and analysed thematically. Results showed that local artisans constructing houses in the flood-prone areas of Msasani Bonde la Mpunga were well informed of various flood-resilient and adaptation measures, including engineering-related skills (structural) and tacit categories. These measures include raising/elevating ground floor levels, using reinforced foundations and aprons around the foundation plinth and using waterproof building materials such as waterproof cement. However, using stilts/columns was rarely applied because it was conceived as a complex and costly flood construction measure. The article concludes that most local artisans in the Msasani Bonde la Mpunga settlement had good and relevant knowledge to enhance flood resilience and adaptation of buildings. However, they require the technical proficiency of professionals. The article calls for regular training and inseminations of flood-resilient construction techniques for local artisans. Such training will blend the engineering and local knowledge/expertise fundamental for enhancing sustainable urban planning and resilient building construction in flood-prone informal settlements. Local artisans' training should be synchronised with sensitisation to enlighten communities about the significance of utilising skilled and trained local artisans.

KEYWORDS: Flood-prone, resilience, adaptation, local artisans' knowledge, informal settlement.

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1. INTRODUCTION

Globally, informal settlements contribute significantly to housing the majority of urban residents in developing countries despite negative perceptions portrayed in such areas. This is because informal

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settlements substantially address housing problems for low-income people, especially in developing countries (Sakijege, 2019; Zhang, 2016).

Despite their disproportionate exposure to climate change-related hazards such as floods and heat waves, informal settlements offers dwelling spaces of nearly a billion people in the world (Abunyewah et al., 2018; Dodman et al., 2022; Satterthwaite et al., 2020; UN-HABITAT, 2020;). Informal settlements are often situated in the hotspots of flood plains, including valleys, marshy areas, and watercourses (Abunyewah et al., 2018; John, 2020; Richmond et al., 2018; Sakijege et al., 2014). About 19 per cent of the world population is directly exposed to substantial risks during 1-in-100-year flood events (Rentschler & Salhab, 2020). Therefore, building houses in such areas is in a way risky. However, due to population density growth and the inability of the government to provide adequate housing in cities (Richmond et al., 2018), low-income urban residents opt for informal settlements, including the ones that are often vulnerable to flood risks, poor construction activities (Abunyewah et al., 2018; Amoako & Inkoom, 2018; Risi et al., 2013) accentuate flood skills. This has been observed in most poor countries, including Tanzania.

Builders in flood-prone informal settlements in many developing countries enlist the engagement of professionals and local artisans to apply flood-resilient and adaptive construction knowledge and skills to avoid vulnerability and flood exposure (John, 2015; Kikwasi & Mbuya, 2019). This study focuses on the local artisans' knowledge of construction in flood-prone areas. The term 'local artisans' is associated with diverse interpretations denoted by a galaxy of synonyms, such as informal craftsmen, construction craftsmen, draftspersons, masons, casual builders, and master craftsmen (Mselle & Alananga Sanga, 2017; Smith, 2001). According to Mselle & Alananga Sanga (2017), local artisans entail people whose construction knowledge emerges informally through skills transfer mechanisms or learning by doing (Mselle & Alananga Sanga, 2017). This study adopts 'local artisans' because this is a sense of interpretation shared and well understood by most scholars who have written on the subject or related issues in the context of Tanzania (Kikwasi & Mbuya, 2019; Mbuya et al., 2018; Mselle & Alananga Sanga, 2017; Sakijege et al., 2012; Sakijege et al., 2014; Sakijege, 2019).

The choice of local artisans in flood-resilient construction is commensurate with house builders' income (Kikwasi & Mbuya, 2019; Mbuya et al., 2018). This choice suggests a positive co-existence between vulnerability and disaster resilience/adaptation, denoting that resilience and adaptation can be related to "strength in the presence of stress", as Usamah et al. (2014) view. Because most residents in informal settlements are regarded as less fortunate, they are most likely to opt for the services of the local artisans. Scholars have noted that constructing buildings in flood-prone areas is challenging because of exposure to floods, economic limitations of house owners, and inadequate housing construction techniques (Hambati & Yengoh, 2018; Usamah et al., 2014). Some scholars' concerns hinge on residents' limitations, while others have focused on local artisans. These arguments partly explain why some buildings may not have flood-resilient/adaptive measures in flood-prone informal settlements.

Given the many challenges builders in house construction in flood-prone areas experience, it would be expected that urban plans and regulations consider these aspects. However, this is not often the case, as scholars have noted that many urban planning and development policies in most regions of the world tend to exclude flood-prone informal settlements and their dwellers from development planning considerations (Dangol & Carrasco, 2019; Satterthwaite et al., 2020). For instance, in Tanzania, the urban planning policies view flood-prone informal settlements as environmentally fragile land unsuitable for residence (URT, 1999; URT, 2004). However, despite these prohibitive policies, urban dwellers are increasingly constructing houses in these areas (Abunyewah et al., 2018). This tendency is attributed to the rapid urbanisation trend, inadequate urban planning policies, and city population growth, which consequently accentuate the demand for housing high (Jahangir, 2018). The urban planning policies have therefore tended to ignore the reality of people with low incomes contributing to the vulnerability of residents (Dangol & Carrasco, 2019). However, residents continue to take initiatives for flood-resilient/adaptive knowledge in building construction in flood-prone areas.

Building construction in flood-prone informal settlements involves informal construction processes using self-help techniques (Feliciano et al., 2022; Satterthwaite et al., 2020). These include using local artisans in building construction instead of professionals like architects, planners and engineers with qualifications and knowledge of flood-resilience/adaptive measures. According to Feliciano et al. (2022), housing construction measures in flood-prone informal settlements are usually organised by the house owners, who hire house builders with practical construction knowledge. Conversely, other studies (Goldwyn & Gonz, 2022; Kikwasi & Mbuya, 2019) note that houses in many flood-prone informal settlements are informally built mainly by engaging builders, friends, or family members who acquired construction knowledge mainly through learning by doing as local artisans. The use of local artisans in building construction has been witnessed in the poorest countries, but have eluded the scholars' attention.

A few studies have been conducted focusing on local artisans' knowledge of flood-resilient/adaptive buildings in informal settlements. Moles et al. (2013) recognise the contribution of local artisans, local people, and strong knowledge of their local culture and general context critical for resilient buildings to floods. Other scholars have acknowledged community resilience in disaster risk settlements, including flood-prone areas (Hambati & Yengoh, 2018; Petersson et al., 2020). However, these studies did not address the knowledge of the local artisans in contributing to community resilience in flood-prone informal settlements. Studies on how to make buildings flood-resilient/adaptive have been conducted, particularly on the engagement of professional knowledge, paying little attention to local artisans (Brisibe, 2018; Brisibe & Pepple, 2018). Studies have documented the necessity of advancing building materials and material technologies (Anh & Phong, 2014; Golz et al., 2013; Golz et al., 2015); the architectural design innovations to increase flood resilience (Anh & Phong, 2014; Proverbs & Lamond, 2017); improving planning regulations, laws, policies and building codes that cover the aspects of severe, and extreme flood related climate change situations (FEMA, 2011; Rogers et al., 2015) are underscored.

In the context of Tanzania and Dar es Salaam City, in particular, there is limited literature on flood-resilient knowledge and adaptation of buildings by local artisans. The existing studies (e.g. Kikwasi & Mbuya, 2019) have mainly focused on construction knowledge in flood-prone informal settlements using different approaches and methods, including experimental methods, to assess the vulnerability of buildings to floods. They note that most buildings were vulnerable to floods attributing this to local artisans' lack of knowledge/skills used mainly by residents in construction, among other factors. The study by Kikwasi & Mbuya overlooked the significance, role and contribution of local artisans' knowledge in reducing vulnerability of buildings to flooding. Similarly, using quantitative and qualitative methods, Sakijege et al. (2014) investigated adaptation strategies to flooding in flood-prone informal settlements. In their study, the authors do not bring out the local artisans' knowledge and how this could be tapped to enhance resilience in building construction. Just like Kikwasi & Mbuya, Sakijege and others discourage the use of local artisans while, in reality, poor residents may not afford or have no viable alternative.

In addition to the limitations in the studies above, there is still a scanty body of literature concerning local artisans' knowledge of flood-resilient construction and adaptive buildings in Tanzania, particularly from a qualitative method perspective, while in reality they are actively involved in building construction. This is the rationale for conducting this research, focusing on the "Msasani Bonde la Mpunga' flood-prone informal settlement in Dar es Salaam City. This study addresses the basic research question: What knowledge do local artisans possess and use in constructing flood-resilient and adaptable residential buildings in flood-prone informal settlements? This question aligns with the acknowledgement that local artisans' knowledge requires exploring and documenting, especially regarding flood resilience and building adaptations (Iloka, 2016; Kikwasi & Mbuya, 2019). This study offers valuable contributions to literature. Firstly, it uncovers the diversity of knowledge local artisans possess, ranging from tacit to engineering (structural). It also exposes the knowledge spectrum of the communities that mainly engage local artisans in designing and constructing buildings in flood-prone areas. Therefore, this study is a work-up call to local actors and authorities to proactively help and support local artisans to address grey areas of flood resilience and adaptation among low-income housing in flood-prone informal settlements, where local artisans are popularly and largely used as key actors.

The preceding section has provided the context and background to the study. The subsequent sections are organised as follows: Section two reflects on the relevant literature and concepts. Section three explains the study's methodology, whereas section four presents and discusses the findings. Finally, section five provides conclusions and recommendations drawn from the study.

2. LITERATURE REVIEW

2.1. Local artisans' knowledge: reasons and implications for resilient construction

This study's focus is on the knowledge of local artisans stemming from the fact that they are primarily engaged in local construction processes, including flood-prone areas, especially in informal settlements (Mbuya et al., 2018; Kikwasi & Mbuya, 2019; Sakijege et al., 2014; Sakijege, 2019). Islam et al. (2013) note that in Bangladesh, about 83% of the houses constructed in flood-prone areas followed non-engineering construction techniques, as they mainly employ local artisans' construction knowledge to increase flood resilience in their residential buildings. This phenomenon is consistent with another study by Sakijege et al. (2014) conducted in flood-prone informal settlements of Keko Machungwa, Dar es Salaam, Tanzania and Sangkrah in Indonesia. In these settlements, Sakijege and others observed that about 89% and 82%, respectively, of the house owners in Keko Machungwa and Sangkrah engaged local artisans instead of professionals in constructing their houses. Sakijege's (2019) study at the Keko

Machungwa settlement adds that nearly 95% of the buildings were built through informal construction processes, such as; using untrained local artisans without consulting professionals. Evidence from Tanzania and Bangladesh indicates that local artisans are popularly utilised.

Scholars have highlighted several factors that determine the engagement of local artisans. Goldwyn & Gonz (2022) state that hiring local artisans in informal construction processes, particularly in flood-prone areas, is driven by various factors, including the need for affordable and accessible housing, weak regulatory housing construction enforcement, house owner preferences, and builder experiences. A study by Ahadzie et al. (2016) in Kumasi, Ghana, established that a score of urban communities was aware that living in a flood-prone informal settlement implies a high risk of flooding and were constantly anxious during the wet seasons. However, they felt that there was nothing they could do without government support. This observation may represent a range of reasons, including a lack of resources to construct more flood-resilient buildings. Likewise, Kikwasi & Mbuya (2019) reveal that house owners in flood-prone informal settlements hire local artisans for housing construction because of limited income (low affordability), ease of access, availability and flexibility of engagement, which professionals cannot guarantee to offer. This argument is consistent with Sakijege's (2019) observation that the frequency of hiring local artisans instead of professionals/experts in constructing buildings in flood-prone settlements is linked to low prices/charges they offer compared to using professionals. This situation explains why studying and documenting their knowledge of flood resilience and adaptation of buildings in flood-prone informal settlements accommodating the bulk of the urban population is important.

Other factors noted for using local artisans are related to regulatory enforcement and the costs involved. Studies show that the local authorities and municipal professionals rarely enforce code provisions or monitor construction works in flood-prone informal settlements (Clancy et al., 2020; Sakijege, 2019). Technically, all builders (formal and informal) are required to seek the Local Government Authority's permits to construct a building in urban areas. However, builders utilise local artisans because they operate outside the formal processes (urban planning regulations), as their operations are hardly monitored. Local artisans construct houses in flood-prone areas using local knowledge and experience. This condition can be considered a crucial approach to adopt because even countries that have tended to use and invest heavily in structural engineering measures of flood prevention using professionals still report regular flood incidences (Kumar et al., 2021). Nevertheless, this does not mean that local artisans' knowledge of flood resilience supersedes that held by professionals. Iloka (2016) asserts that local knowledge is valuable and worth using to rescue urban residents from the consequences of floods affecting their buildings. This argument concurs with Uphoff's (1991) viewpoint that while it cannot be assumed that local people have all the needed technical construction knowledge, it should neither also be assumed that they do not have anything to contribute. In addition, the services of local artisans are cheaper than those of professionals. It can be noted that local artisans offer reasonable building construction prices/charges that favour house owners' affordability of increasing flood resilience/adaptation in flood-prone informal settlements (Sakijege et al., 2014; Sakijege, 2019). However, there has been doubt concerning the knowledge of local artisans despite the fact their services are widely used.

There has been concern regarding local artisans' construction knowledge in flood-prone areas. Scholars have argued that the knowledge that local artisans possess might not be adequate to enable them to apply resilient construction measures in informal settlements (Mbuya et al., 2018; Kikwasi & Mbuya, 2019; Sakijege et al., 2014; Sakijege, 2019). Goldwyn & Gonz (2022) raise concerns that using local artisans may contribute to doubtable housing design details and the consequent structural performance that may extensively vary among local artisans. They add that this can generate unsafe housing situations, with house owners (builders) perceiving them as safe, whereas the houses have substantial flood hazard vulnerabilities. This argument suggests that despite appreciating local artisans' flood-resilient/adaptive construction knowledge, it requires an overstretched expert/professional knowledge. If anything, the two knowledge and skills need to be blended. This view further suggests that the local artisans' knowledge of flood resilience/adaptation construction measures requires checks and balances to enhance resilience in safeguarding local communities in flood-prone areas. In other words, it can mean that the local artisans' knowledge of flood-resilient/adaptable buildings is useful if it can respond to housing designs and construction.

It is also worth noting that professionals primarily work with local artisans in building construction processes, particularly in developing countries, notably in informal settlements, including flood-prone areas (Goldwyn & Gonz, 2022). As such, the scholars argue that it is sometimes challenging to identify their line of separation, especially when some flood-resilient/adaptive measures employed appear similar. This argument indicates that housing designs and building construction knowledge from the local artisans' perspective is vital and a prerequisite in flood-resilient and adaptable buildings. Although

professionals and local artisans sometimes work together, poor residents rely entirely on the latter rather than the former. On the other hand, it is not surprising that local artisans who have closely worked with professionals such as architects and engineers gradually learn and improve their knowledge and skills.

2.2. Resilience and adaptation: a conceptual understanding

In assessing the local artisans' flood-resilient knowledge level in this study, two recurring terms played pivotal roles in the debate. These are 'resilience' and 'adaptability'. In this study, resilience and adaptability are commonly applied and sometimes used interchangeably; hence, they are worth clarifying. The reason is that the two concepts are mutually inclusive in reducing buildings' vulnerability to floods. As such, it was essential to define these concepts delineating how they are operationalised in the study. The critical point to note here is that the two terms (resilience and adaptability) used in this study are debatable in the literature. Understanding the existing discourse regarding the concepts was vital to comprehending local artisans' knowledge of flood resilience and building adaptations.

As for resilience, scholars argue that a system is resilient if it can demonstrate the capacity to continue or adapt by changing to attain an adequate level of functionality and structure (Hillmann & Guenther, 2021; UNISDR, 2010). The International Strategy for Disaster Reduction (UNISDR) equates this capacity to a degree to which such a system can combine possible resources, strengths and attributes to help minimise and control disaster risks while strengthening resilience. Thus, a flood-resilient system entails the ability to respond to flood risks and effects with the capacity to prepare for them (Miguez & Veról, 2017). Also, Ferreira et al. (2021) see resilience as the ability of the system to recover its planned functionality or resume its original situation after it has experienced a disturbance. These scholars' arguments show that the definition of resilience is diverse and context-based. Since the context of this study concerns building designs and construction in flood-prone areas, it adapts a definition by Hooli (2016). Hooli argues that in terms of building designs, resilience entails making buildings, regions and communities capable of mitigating threats resulting from exacerbated weather and climate change by engineering buildings to face severe weather impacts, including using waterproof building materials impermeable to water damage.

At the property or household level, measuring flood resilience can be categorised mainly as water inclusion and exclusion strategies (Quandt, 2018; Proverbs et al., 2017). The water inclusion strategy entails using materials in building construction with water-resistant capabilities, such as water-resistant plasters, paints on the walls and materials with plastic units for designing and constructing spaces likely to have water, notably the kitchens (Olatunji & Adebimpe, 2023). The ones related to water exclusiveness involve integrating building structures with the ability to prevent water entry inside the building or property, such as flood barriers and dry-proofing materials (Proverbs et al., 2017). These categories are useful in exploring the local artisans' knowledge level of increasing flood resilience and adaptability of buildings in flood-prone informal settlements. Escarameia et al. (2012) propose that building resilience can be attained through measures such as using suitable building materials, construction techniques and flood-preventive products in particular. The proposal by Escarameia and other scholars reflects water inclusion and exclusion strategies.

It is also noted that enhancing building codes and infrastructure facilities, improving building services, the capability of anticipating and protecting assets, suitability of understanding risks by local authorities and community dwellers, sustainable urbanisation involvement from the local government, community involvement and putting values that emphasise local knowledge are critical (Dianat et al., 2021; UNISDR, 2010). With the aim of this study, resilience is studied in relation to knowledge of designing and constructing residential buildings against floods in flood-prone informal settlements using the local artisans' knowledge.

In so far as adaptability is concerned, Walker et al. (2004) describe it as the ability of actors in a given system with the capacity to influence resilience. Thus, adaptability may differ from resilience because it may not need measures to resist or stop floods but allows buildings to function despite flood occurrences (Norizan et al., 2021). Regarding building design and construction, adaptability needs building designs that are modifiable, adjustable to users and functioning despite flood events. According to Kronenburg (2015), making a building flood adaptive requires adhering to the capacity to adjust to diverse or varied functions, users, weather and climates or adjusting to changes in climate.

3. RESEARCH METHODS

3.1. The study area

The study was conducted in the Msasani Bonde la Mpunga, Dar es Salaam city. Being among the Coast Regions in Tanzania, the city was selected for the study because of its vulnerability to flood risks (CLUVA, 2013). On the other hand, "Msasani Bonde la Mpunga" is a flood-prone informal settlement located within an area comprising both formal and informal settlements. Previous studies show that Msasani Bonde la Mpunga settlement is approximately 0 to 3 up to 4 meters above the mean sea level (Salukele et al., 2017; Juma & John, 2018), thus prone to floods. However, there are variations in altitudes, with some parts raised between 4-10 metres due to sedimentations, alluvial deposits and landfilling done to prevent floods (Kemwita et al., 2022). Msasani Bonde la Mpunga is bordered by the Indian Ocean on the north and east, Msasani Road on the east, and Maandazi Road on the south-eastern, while old Bagamoyo Road is on the west and south-western side (Figure 1). Initially, before housing construction densified, the settlement had a natural stormwater drainage way that was used to channel water from higher parts of Dar es Salaam city towards the ocean (Salukele et al., 2017). As such, flooding over the past was manageable as opposed to the currently overstretched housing densifications in the settlement.

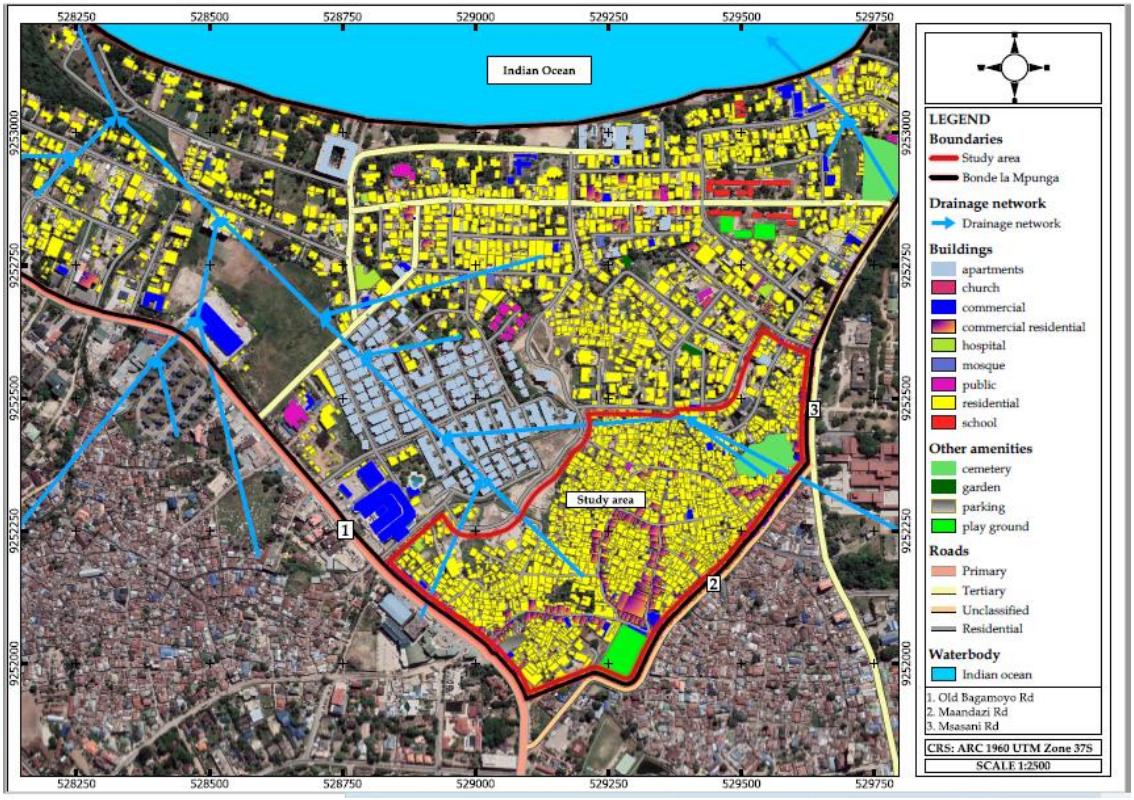

Figure 1. Location of Msasani Bonde la Mpunga; case study area
Source: Authors' drawing (2022)

The study was conducted in the often flooder segment of the settlement inscribed in red, characterised by depression (Figure 1). This area was considered information-rich for exploring local artisans' knowledge of flood resilience and adaptation. Yin (2009) observes that extensive exploration of real-life context is effectively carried out in information-rich areas. Therefore, this case study area was selected using various criteria. These include informal settlements in flood-prone areas, a settlement experiencing regular flooding, a settlement densely built regardless of flood occurrences, and a settlement formally acknowledged as flood-prone areas. Based on the report by the Pan-African START et al. (2011) regarding the flood level extent in informal settlements and the criteria stipulated above, Msasani Bonde la Mpunga was ranked among the first top-five flood-prone informal settlements in the city; thus, worth considering as a study area.

3.2. Research design

The article adopted a qualitative case study design to explore local artisans' knowledge of flood resilience and adaptation of buildings in flood-prone areas. The case study design opted to enable an in-

depth exploration of local knowledge regarding flood resilience and adaptation of buildings. Yin (2018) elucidates that case study design enables an in-depth exploration of the social phenomenon and the study of a contemporary phenomenon in a real-life context. As noted, flooding in the area started recently following the housing densifications, encroachment and blockage of the natural storm drain. Also, the design was considered suitable because it helps to understand how knowledgeable the local artisans are in constructing residential houses in flood-prone informal settlements.

3.3. Sample size and sampling procedures

A total of 20 local artisans were face-to-face interviewed. The number was reached following the recurring responses from the participants after indicating that no new information was emerging during interviews (saturation point). Participants were purposively selected through a snowballing sampling technique. Kothari (2004) argues that purposive sampling is desirable when the universe is small and a known characteristic is to be studied intensively. Local artisans were identified through snowballing because they were challenging to locate as they operate informally. Initially, the Ward leaders in the settlement were asked to initiate the exercise by identifying a few commonly known local artisans constructing houses in Msasani Bonde la Mpunga. Two local artisans well-known by the Ward leaders were nominated, and their mobile phones provided to ease their availability. These local artisans then continued identifying more participants as the interview process progressed. In addition, one group of 8 local artisans was selected for the focus group discussions after the face-to-face interview sessions was completed. This group of artisans was selected during the face-to-face, in-depth interviews. The selection based on experience the artisans had on building construction knowledge in flood-prone areas based on their views, suggestions and arguments.

3.4. Data collection methods/tools

The data collection methods employed in this study were interviews and focus group discussions. This fieldwork was conducted between February and April 2021 and supplemented in August 2021. The supplement data was sought from the local artisans who were missed during the first batch of interviews but considered to possess vital information regarding the knowledge of flood-resilient/adaptive buildings. Both methods were conducted concurrently (collected parallel, analysed separately, and merged during reporting), as posited by Creswell (2014). The process started with face-to-face, in-depth interviews with each local artisan asked to provide individual knowledge of flood resilience and adaptation of buildings in the study area. The local artisans were interviewed at their home places, construction sites or common spaces in the study area where they meet for gambling while waiting for any emerging construction works from the households/clients. As they operate informally, it was sometimes challenging to dentify them, so snow-balling techniques were useful. The interview covered issues related to local artisans' knowledge of making buildings flood-resilient/adaptive, such as materials and technicalities, among others. Most interviews were scheduled on weekends, especially on Sundays, as most local artisans were available at home, free from work-related preoccupations. The Interviewees who were missed at home during the interview period were scheduled for other days. Open-ended and semi-structured interview questions were used, which enabled participants to express themselves freely. This facilitated collecting in-depth knowledge concerning flood-resilient and adaptation of buildings.

In-depth interviews were conducted in Kiswahili language between 45 minutes to 1-hour time. Focus group discussions (FGD) with the selected local artisans were used to capture any possible flood-resilient knowledge gaps skipped during in-depth interviews. This method enhanced the information collected from individual local artisans' interviews. The FGD was held at a particular open area; the local artisans call "*Kijiweni*[1]", where they usually gather and wait for clients. Between 1-2 hours were spent discussing issues concerning the artisans' flood-resilient and adaptive knowledge and how it was being applied or otherwise. During the discussions, equal chance was provided for each participant to contribute their opinions and ideas. In both methods (interviews and the focus group discussion), consent was sought from the participants to permit recording of the responses. Responses were transcribed into English for the analysis process.

[1] "Kijiweni" is a typical Swahili word where people, in this study the local artisans meet for making stories and playing games.

3.5. Data analysis

For data analysis, translated and transcribed interviews were coded and organised based on pre-determined themes and interpreted. The participants' responses in terms of sentences and paragraphs were coded and arranged in rows and columns for thematic analysis. Concepts were formed from the interviews by linking the correlated codes. Such concepts were then classified into six themes (sections 4.1 and 4.2) and analysed with the aid of qualitative data analysis (MAXQDA), Microsoft Word (MS) and Excel Programs.

4. RESULTS AND DISCUSSION

In this section, results are presented and discussed. The results are categorised into two themes. The first category presents and discusses local artisans' knowledge of flood-resilient and adaptation measures/techniques in residential buildings. The second category discusses the sources of knowledge local artisans possess and their variations in building construction.

4.1. Local artisans' knowledge of flood-resilient adaptation measures/techniques

Local artisans' knowledge and adaptation measures/techniques were assessed through criteria the that included familiarisation with flood resilience and building adaptation, flood preventive architectural features, desirable plinth height, optimum foundation design category used and determining the ground floor height as summarised in Table 1. The criteria and flood-resilient measures were established epistemologically based on the various scholarly works concerning flood prevention and mitigation measures of the buildings constructed in flood-prone areas (Brisibe, 2018; Brisibe & Pepple, 2018; Jabeen et al., 2010; Oladokun et al., 2017; Proverbs et al., 2017; Thorn et al., 2015). These criteria and measures are presented and discussed in the subsequent sections.

4.2. Familiarisation with flood resilience and building adaptation

Regarding familiarisation with flood resilience, mitigation and adaptation measures, as shown in Table 1, results show that all (20) local artisans in Msasani Bonde la Mpunga were familiar with and knowledgeable about why they had to raise foundation plinth walls/floors and defensive walls. The respondents reported that many of the residents in Msasani Bonde la Mpunga applied these measures and believed that such measures were important for flood-resilient and adaptive interventions for buildings constructed in flood-prone areas. More so, they were affordable. It was also reported that raising the foundation plinth walls is a common practice which can be conducted even in non-flood-prone settlements to prepare for unforeseen future flood events and for aesthetic reasons/purposes. In addition, using defensive walls, such as fence walling and short-resistant walls around the veranda and on the entryways, were reported among flood measures that the local artisans mostly knew. Portraying familiarisation with flood resilience and adaptation of buildings to flooding, one of the interviewees noted:

> "*To prevent floods, one must be conversant with various techniques. Firstly, we prepare drainage systems around the houses to protect residents from floodwater. Then, we elevate the foundation plinth level to a height of not less than seven courses equivalent to 1.05m of 230mm thick masonry block walls above the ground. This height is based on the past flood water mark of the nearby houses' walls. Further, we also built an apron wall around the houses finished with a smooth sand cement surface. We apply waterproof cement to prevent the building walls from floodwater penetration and protect such walls from moulds caused by the effects of floodwater contact on the walls"*[2].

Another participant in the FGD had the following to say:

> *"I agree with my fellow concerning the techniques we use to construct our houses against floods. But, the first and foremost intervention we pursue when a house is hit by severe flooding is to build a short wall around the house to reduce flood effects before any other strategies are pursued"*[3]

The preceding quotations show that even without input from professionals, the local artisans have some notable knowledge to enhance flood resilience and make adaptive buildings through structural solutions, such as floodwater entry preventive techniques. This situation indicates competence among local artisans regarding flood prevention using structural engineering solutions in Msasani Bonde la

[2] A reaction from a local artisan aged 53 years during a face-to-face interview in Msasani Bonde la Mpunga held on 05.03.2021

[3] A reaction by a male participant aged 45 during FGD at Bonde la Mpunga, March 2021

Mpunga. However, these measures were supplemented by the knowledge of providing drainage systems and sandbags to help reduce the speed of flood water that may flow into the buildings. However, such measures serve as immediate flood prevention measures rather than offering permanent flood resilience solutions. Nguyen et al. (2021) note that although structural measures revealed in Msasani Bonde la Mpunga to flood resilience are popular flood mitigation measures in buildings, they are inadequate flood-resilient and adaptation measures because they can only work better in less severely flood-impacted localities.

Table 1. Local artisans' knowledge in flood-resilient construction and adaptation measures

Knowledge Assessment Criteria	Flood resilient knowledge and adaptation measures/techniques	No. of local artisans (out of 20)
Acquaintances with flood resilience, mitigation and adaptation	Raised floor level and reinforcement foundation	20
	Use of water proof techniques	15
	Use of water proof building materials	7
	Defensive walls	20
	Use of adaptable spaces and services	Nil
Architectural features supplemented as preventive measures against floods	Raised floor levels of the foundation	20
	Use of water proof techniques	15
	Construction of aprons around the buildings' envelope	20
	Defensive walls	20
	Use of water proof building materials	20
	Creation of emergency exit and escape routes	Nil
Desirable height to raise the ground floor	0-0.6m	4
	0.6-0.9m	12
	1-1.5m	20
	1.6-2.0m	Nil
	Over 2.1m	Nil
Optimal design type for raised ground floor	Use of stilts/columns	4
	Creating water drainage (path) around or under building	4
	Filling of whole raised floor	20
	Creation of basement	4
Raised ground floor height determinants	Reference made to official datum point	Nil
	Reference made from main access road	12
	Reference made from previous flood water mark	20
	No, reference point used to determine floor level	Nil

The knowledge about raising the foundation plinth walls and associated techniques for preventing floods witnessed in Msasani Bonde la Mpunga in Tanzania is also practised in other flooding settlements. Sakijege et al. (2014) study in Keko Machungwa, Tanzania, and in' Surakarta, Indonesia, flood-prone informal settlements report that the residents in both case study areas were aware of flood problems and enlisted the services of local artisans for relevant flood prevention (mitigation) measures. The local artisans employed a variety of structural and non-structural measures to adapt to the impact of floods, including retaining walls raising stairs and plinths, among others. These measures were reported as affordable and easy to use. It is further argued that despite local artisans' awareness of structural strategies for checking flooding, these measures still require scrutiny regarding their effectiveness in mitigating building damage (Nguyen et al., 2021). This phenomenon may point to the fact that the practices of local artisans concerning flood resilience and building adaptation for effective engineering solutions are still limited.

This study reveals that three-quarters (15 out of 20) of the interviewed local artisans were aware of using waterproofing measures/techniques to complement the raised ground floor/foundation plinth walls (Table 1). Such measures include using building materials such as cement admixtures, chemical lining, waterproof cement, and wet and dry-proofing techniques. However, it was noted that the most reported waterproofing knowledge techniques include using Damp-Proof Membrane (DPM), Damp Proof Course (DPC), waterproof cement and admixtures. These materials were reported as locally available and easy to use. Of these techniques, DPM, DPC and waterproof cement were highly used as flood-resilient and adaptive materials in Msasani Bonde la Mpunga. Thomsit-Ireland (2018) in the UK reveals corresponding

findings, noting that DPM and DPC are regarded as regularly used building materials for they act as barriers for water rising from the ground through capillary actions. Apart from DPM and DPC, the other waterproof materials used in flood-prone areas entail materials such as waterproof cement admixtures, chemicals, asphalt or bitumen-based linings, rubber or plastic sheet layers and other applications for increasing resilience (Brisibe & Pepple, 2018; Brisibe, 2018). This is corroborated by Escarameia et al. (2012), who argue that using DPM and DPC materials in flood-prone areas helps to reduce floodwater impacts and increases flood resilience and adaptation by preventing floodwater penetrations or accommodating it to lessen building wall damages.

Although most local artisans in Msasani Bonde la Mpunga showed adequate knowledge of waterproofing measures and techniques, less than half demonstrated knowing waterproofing materials use (Table 1). This finding implies that the knowledge concerning waterproofing materials used among local artisans in Msasani Bonde la Mpunga is minimal despite their understanding of waterproofing techniques/measures. Local artisans, who demonstrated having good and relevant knowledge of waterproofing materials, reported that such materials are more effective in protecting (increasing resilience) houses from flood water penetrating inside the houses. This argument aligns with Sakijeges et al. (2014) findings that local artisans engaged in constructing residential buildings have limited knowledge about waterproofing techniques (measures). Local artisans could not acquire knowledge of waterproofing techniques because most houseowners were adamant about buying waterproofing materials due to financial limitations. The implication is that the knowledge about using a certain flood-resilient and adaptive measure can be limited by lack of practice, which ultimately affects the pace of increasing flood resilience and adaptation efforts. Indicating the significance of the practice, one interviewee attested:

> *"I have lived in Msasani Bonde la Mpunga from 1990. Before I came to this settlement, I already had construction knowledge acquired through my fellow local artisans. When I arrived here, some house owners recognised I was a builder. They started contracting me for some construction work. By that time, my construction knowledge was too general. By working together, I had to learn more about constructing houses in flood-prone areas from experienced local artisans. Over time, I gained experience and became accustomed to building houses in flood-prone areas. Currently, I am widely engaged in building houses for my customers, even in other flooding settlements across the city."*[4]

The quotation above conforms to the adage that 'practice makes perfect'. It indicates the power of the experience that a local artisan could acquire through intuitive learning and eventually build trust among house owners who hire him for their house construction works in a flood-prone environment. It further amplifies the fact that if residents cannot hire local artisans and construct resilient and adaptive houses, the local artisans' knowledge would remain limited.

As for the use of adaptable spaces and services, such as elevated spaces for emergence exits and raised electric sockets/switches, respectively, results showed that none of the local artisans in Msasani Bonde la Mpunga possessed such knowledge (Table 1). However, these are essential flood-resilient/adaptive mitigation measures. Likewise, Brisibe (2018) adds that in Yenagoa flood-prone settlements, no builders designed and supervised residential houses with inclusive escape routes and emergency exits in case of severe flood impacts. Sharma (2021) notes that residents living across the Lower Karnali River Basin of Nepal had little knowledge about making adaptive spaces and measures for flooding prevention, particularly on the escape means in case of flood emergence. Adaptable spaces, escape routes and services are among the architectural features that safeguard households' safety if buildings face severe floods (Thorn et al., 2015). Kim et al.(2022) suggest that adaptable spaces and services such as escape routes and emergence exits during floods are important because they can help survivors move towards the elevated (higher grounds) positions and wait for rescue.

The lack of adaptable spaces, exit routes, and emergency escapes in buildings represents a scantiness of knowledge among local artisans. It also indicates that it is difficult for rescue people to save house owners during severe floods, specifically those with physical disabilities, pregnant women, children and the elderly, if such knowledge is scantly known. Also, it suggests that urban dwellers in flood-prone settlements are not yet acquainted with the escape and adaptive space considerations in increasing flood resilience and adaptive capacity to live with floods. Therefore, they need to inform the local artisans to incorporate adaptable spaces, exit routes, and emergence escapes. This view suggests that flood-resilient and adaptive buildings related to adaptable spaces' knowledge constructed in flood-prone areas are still low among local artisans and communities. This viewpoint is especially true for flexible spaces and services in building design constructions in such areas.

[4] Responses from the same local artisan supplementing to his previous reactions in apostrophe[3].

4.3. Flood preventive architectural features

Regarding the architectural features added as preventive measures to increase flood resilience and adaptation of buildings, the results in Table 1 reveal that all (20) local artisans were knowledgeable about the apron walls construction around the foundation plinth walling and applying waterproofing materials and techniques. These measures were reported as common flood-resilient and adaptive measures practised to increase flood resilience in Msasani Bonde la Mpunga. For instance, it was revealed that the apron walls constructed around the foundation plinth help to prevent flood water from penetrating the house foundation. Apron walls help avoid wetting the foundation plinth walls or mould growth around the walls from floodwater. This assertion suggests an adequate understanding concerning house foundation protection to increase flood resilience and adaptation capacity. It was also noted that using apron walls as a structural engineering measure for flooding helps reduce flood risk by delaying flood water penetration that could damage building foundation walls. However, this does not work as a permanent flood prevention solution, as various scholars argue, since threats from flooding have continued to increase (Chen & Lin, 2018; Sayers et al., 2015).

From Table 1, only 4 out of 20 local artisans were conversant about architectural features, such as suspending buildings on slits (columns) to allow spaces under the ground floor to ensure floodwater flows on either side. This finding represents imperative need to know such architectural features among artisans in Msasani Bonde la Mpunga. Despite being critical facilities in flood prevention, other architectural features, such as emergency exits and escape routes, were relatively unknown by most local artisans, as covered in section 4.1. As for the reason (s) for this shortfall, the artisans pointed out that such flood measures (facilities) required in-depth knowledge and expertise to implement, and they did have such expertise. Moreover, the artisans reported that only the well-off house owners could afford such facilities. However, most of the Msasani Bonde la Mpunga residents are low-income earners. Similar findings were reported by Brisibe (2018), noting that as residents strived to save cost, about 90% of the houses constructed in Yenagoa, a flood-prone settlement, used fully covered foundations with earth soil filled before the concrete bed was applied. Local artisans practised this despite knowing other flood resilient and adaptive measures of flood prevention, particularly structural measures such as using stilts (columns) and introducing basement floors. Local artisans mostly comply with the house owners' level of affordability.

4.4. Desirable height to raise the foundation plinth

All (20) local artisans in Msasani Bonde la Mpunga suggested a foundation plinth height range between 1-1.5 metres or beyond (Table 1). Such measurements of heights were reported to be the appropriate levels preferred for raising the buildings to ensure flood prevention and increase resilience. Such heights were considered reasonable based on the experience of the past floodwater level in the settlement observed on the houses' walls. It was reported that floodwater in Msasani Bonde la Mpunga often reaches below window sill levels unless under exceptional severe cases of flooding. This situation suggests that the appropriate level to raise the foundation height to prevent floods can be learned from the experiences of floodwater observed over time. Explaining the desirable height to raise the foundation plinth, one of the participants in the FGD remarked:

> *"As local artisans, we know how to construct houses in flood-prone areas. First, you must ensure your building is elevated enough to prevent flood water from entering the house. As for me, I must ensure that the building is raised to at least three feet, equivalent to 0.9m and not less. Our experience working in this area shows that most flood water depths may reach the window sill level, a height of between 0.9 to 1 metre. Here, we count four courses of masonry blocks with their base laid in six-inches."*[5]

The knowledge about the height range revealed by local artisans in this study does not align with other building codes suggested in other areas practising building codes in flood-prone areas. For instance, the Foreign Exchange Management Act (FEMA) (2011) recommends that buildings constructed in coastal areas, like Dar es Salaam City and those under Special Flood Hazard Areas (SFHA), should be elevated not below 1 foot high (30cm) to exclude flood water entry into the houses. Nevertheless, Xian et al. (2017) offer a different view, arguing that such a raise can reflect only less severity of the hazards determined using the Base Flood Elevation (BFE) but not the generalisation about vulnerability facing the houses. This difference in height determinants suggests that building elevation height in flood hazards should not have a fixed standard as FEMA (2011) proposes but rather be determined based on the context of flood severity incidences. This argument underscores the viewpoint that the knowledge of deciding adequate height to

[5] A response from an FGD local artisan aged 39 at Msasani Bonde la Mpunga March 2021.

raise the building based on the experience of past flood events in flood-prone areas is substantively essential.

In contrast, the American Society of Civil Engineers (ASCE) emphasises that the lowest standard for raising buildings in flood-prone settlements requires adhering to the building codes (Xian et al., 2017). However, this works in areas where building codes that guide building/house designs and construction in flood hazards exist. This phenomenon is nonexistent in the Msasani Bonde la Mpunga, where people build houses without pre-determined guidelines.

Despite the local artisans' knowledge regarding the foundation height range preferred, it was demonstrated that not all houses are raised above the window sill level (Table 1). The reason established was that most house owners lack financial resources. As shown in Table 1, some of the foundation plinth heights of the houses appeared elevated only 0.6 metres high; some are below this height commensurate with the income of households, yet flood enters their houses. This finding supports the findings by Harun-Or-Rashid et al. (2022) in Bangladesh that most buildings constructed in flood-prone areas had plinth walls elevated to at least 0.9 metres above the ground. As such, in the Msasani Bonde la Mpunga settlement, the economic implications may dictate or determine the height/level of the building foundation and sometimes not the extent and context of flood occurrences. These findings are consistent with those reported by ží et al. (2017) in the Czech Republic, who note the low uptake of flood risk mitigation measures due to financial limitations despite flood knowledge. Xian et al. (2017) note that elevating building foundation heights to floods and preventing flood risk mitigation measures require considering the flood hazard, vulnerability and exposure characteristics, including the houses' value, size, lifespan, and ground height.

4.5. Optimum foundation design category used

Concerning the optimum design category of the ground floor level, results show that all (20) artisans had good and relevant knowledge regarding raising the ground floor with complete filling (Table 1). The local artisans claimed that such flood measure is simple and considered cheaper to construct. Most households can afford it rather than complex measures, such as basement creation or building suspensions on stilts/columns, requiring complicated details and costs. Therefore, local artisans had acquired knowledge in raising the ground floor with the complete filling because house owners often gave them such tasks. These revelations are similar to what Brisibe (2018) reports in Yenagoa, where most local builders opt for the complete filling of the foundation plinth rather than better flood preventive measures on the grounds of affordability and ease of comprehension by most local artisans. This observation shows that building owners' affordability level of a certain flood measure can deprive local artisans of knowledge exposure to flood-resilient/adaptive measures. Although the complete filling technique allows flood water to reach the building walls, it was considered an appropriate flood-resilient/adaptive measure. This is because such flood measure provides the possibility of flood water protection from flowing into the houses. In this measure, all foundation ground plinth levels are sealed. Proverbs et al. (2017) note that the raised houses' ground level restricts the prospect of floodwater beyond the protective design level.

On the contrary, results (Table 1) show that less than a quarter of the local artisans interviewed had good knowledge that spaces created under the foundation plinth level and using stilts/columns can increase flood resilience and adaptation of houses. These are considered water paths (drainage) useful for allowing flood water to flow on either side, creating resilience against damage to building walls. The flood measures (stilts/columns) require more reinforced structures, which are expensive and unaffordable for most low-income families despite their usefulness in increasing flood resilience/adaptation. Local artisans refrain from regularly practising such measures. In Msasani Bonde la Mpunga, local artisans demonstrated little awareness regarding complicated flood resilient/adaptive techniques. Only a few artisans (Table 1) proposed creating pathways, such as using concrete culvert boxes and basement floors under the elevated floor levels to homeowners. When interrogated regarding the knowledge of using columns/stilts to suspend the building above the ground level to allow floodwater to navigate either side, a bricklayer local artisan:

> "*Some of us understand that construction of houses using stilts or columns is the best way of preventing floods and building adaptation capacity to reduce severe flood risk. But, the big issue is that most houses built in flood-prone areas are owned by low-income earners. This situation forces us to construct houses in areas that match their limited financial capacity*"[6].

The quote implies that some knowledge can be ignored because of low income or unaffordable, reducing flood prevention opportunities. Van Long et al. (2020) in Can Tho, Vietnam, note that although

[6] A response by an interviewee aged 45 held on 24.03.21 in Msasani Bonde la Mpunga settlement

using stilts/columns increased the safety of buildings during severe and intensive flooding, most house owners' cost of affording such techniques was low. Brisibe & Pepple (2018) confirm that none of the buildings constructed in flood-prone areas of Yenagoa adopted columns/stilts as flood-resilient/adaptive measures because of the low financial affordability of most households.

4.6. Determinants of the ground floor height

Regarding the knowledge of determining heights of the ground floor level to raise the foundation plinths, results as indicated in Table 1 show that all artisans (20) in Msasani Bonde la Mpunga take references from neighbouring houses based on past floodwater mark experiences. This approach includes taking references from the adjacent access road, neighbours' house premises, and normalised water flow direction declared by more than half (12 out of 20) of the local artisans interviewed (Table 1). Such references give the possibility to approximate new levels regarding the next floodwater level to protect buildings from the possible effects of flood damage. Also, it was established that each local artisan employed at least the reference point for determining the building foundation floor level elevation to increase flood resilience and adaptations. Similar findings were reported by Burlotos et al. (2020) in Haiti that the buildings constructed in flood-prone areas used traditional methods, such as taking references from the neighbours' buildings and the neighbouring access roads, but did not use established official datum points. This option offers house owners safety concerning present and future flood events.

4.7. Local artisans' source of knowledge and variations

The criteria and flood resilient knowledge measures (Table 1) used in this article show that most local artisans engaged in constructing buildings in Msasani Bonde la Mpunga have sufficient and relevant knowledge about flood resilience and adaptation of buildings. This is why the study found it critical to probe and explore the sources of knowledge these artisans possess and how such knowledge was acquired. Results (Table 2) established two major sources of the construction knowledge the local artisans acquired it from in flood-prone areas. These include experience gained through learning by doing from their fellow experienced artisans and formal training for those who have attended the Vocational Education and Training Authority (VETA). Osuizugbo & Ibrahim (2022) report similar findings in Nigeria, noting that most young people acquire construction knowledge through formal or informal apprentices. Ikediashi et al. (2012) support this, arguing that formal and informal construction knowledge simultaneously involves in-class directives and on-the-job training.

Table 2. Local artisans' knowledge sources and variations in flood resilient construction

Knowledge sources	No of local artisans (out of 20)	Knowledge variations	No of local artisans (out of 20)
Vocation training (VETA)	5	Ability to read and interpret drawings	5
		Bargaining for work (labor charge estimates)	3
		Making quotation for works	5
		Material cost estimations	5
Experiential knowledge (learning from fellow local artisans)	15	Ability to read and interpret drawings	5
		Knowledge of bargaining for work (labor charge estimates)	7
		Knowledge of making quotation for works	11
		Knowledge of making cost estimations	6
Induced by professionals (architects, engineers or technicians)	Nil	Nil	Nil

Results established that about three-quarters (15 out of 20) of the local artisans interviewed acquired building construction knowledge through intuitive learning (experience) while working with fellow local artisans. In contrast, the remaining quarter (5 out of 20) of the artisans have acquired it from VETA. The ratio of 1:4 indicates that most local artisans in the area received their knowledge through a self-help approach rather than formal training in colleges. Such variations/differences suggest potential knowledge gained through experiences and perceptions worth valuing in the community to influence

policy-making persuasions that could help increase flood resilience and adaptations of buildings. G'Nece (2012) supports this argument, positing that the authorities need to consider local knowledge from the grassroots level since it can help to prevent, mitigate, prepare for and recover from the effects, such as floods. In contrast, none of the local artisans in Msasani Bonde la Mpunga demonstrated sources of knowledge from professionals, such as architects, engineers and technicians (Table 2). However, from experience, it is evident that some local artisans learn and acquire construction knowledge from professionals when they are engaged to work together, even though this was not revealed in the Msasani Bonde la Mpunga area. This source of knowledge is worth adding to other various sources, including those discussed in this study. Combining such knowledge sources can promote tacit and intuitive knowledge obtained from individuals' natural ability. This suggests that the involvement of local knowledge can help reduce flood hazards in housing construction. It can also help improve the limited access to professionals' knowledge required to meet housing construction requirements, especially in developing countries

In addition, it is worth examining local artisans' variations/differences in construction knowledge regarding flood resilience and adaptation of buildings. The variations entailed the ability to read and understand sketches/drawings used in construction and making building material quantity estimates. These differences revealed that all local artisans who were trained in VETA colleges had a proficient understanding of the drawings/sketches used during the design and construction of the kind of buildings erected in Msasani Bonde la Mpunga and materials used than those with intuitive learning (Table 2). The kind of residential buildings dominantly constructed in the study area of Msasani Bonde la Mpunga entailed mostly single storeys category (close to 90%), and the rest few being double storeys (nearly 10%). Single-storey houses were mostly the "Kiswahili"[7] and "Banda"[8] types/styles. Both house types were constructed using masonry blocks for walls, sand, aggregate, concrete on the floors, sand cement screed, floor or wall tiles (few) and waterproof cement on the floors and walls as finishing materials. The roofing was mainly gable, mono-pitch and hips styles with at least a 20-degree angle for the flow of flood water, especially during high rain seasons. Usage of these building materials and techniques requires the knowledge, proficiency, and expertise of the artisans to be able to appropriately use them to increase flood resilience and adaptations of buildings.

This does not mean that the local artisans with experiential knowledge failed to practice building construction in flood-prone areas. Instead, it was revealed that artisans who had learned construction techniques through intuitive approaches might do physical measurements on the ground using tape measures if they do not have designed drawings/sketches on paper. For instance, concerning building material quantity estimates, the local artisans with experiential learning demonstrated purchasing building materials bit by bit until house construction was completed, as they could not prepare a proper schedule of materials and estimates. This phenomenon differed from local artisans with formal training knowledge who demonstrated good and relevant knowledge of estimating the quantities of materials for construction without difficulty. It also reflects the power of education, suggesting that integrating the two knowledge sources can increase construction knowledge in flood-prone areas than relying on only one side of the knowledge base. Eraut (2000) notes this, arguing that having explicit knowledge about something created through reflection or collected from other sources is possible. However, it may be unlikely to replace tacit knowledge because it allows instant response to a phenomenon (Iloka, 2016; Mselle & Alananga Sanga, 2017). This argument suggests that as much formal training knowledge is necessary, it does not completely replace an engagement of the tacit knowledge.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The study has established that most local artisans in the Msasani Bonde la Mpunga are aware of various flood-resilient and adaptive measures of both the engineering and tacit nature. The knowledge sources of such measures is mainly acquired through experiential learning (implicit/tacit knowledge) when working with their fellow local artisans or through self-training. However, a few artisans demonstrated acquired construction knowledge through explicit (formal training) sources, including attending vocational training education. The most reported local artisans' knowledge of flood-resilient and adaptive measures was raising the foundation walls, applying waterproofing materials techniques, and constructing short-resistant walls and aprons. However, other flood-resilient/adaptive measures,

[7] "Swahili houses" house types with a double bank system, i.e., having a corridor (passage) in the middle separating rooms on the left and right sides with a verandah at the rear and front part of the house

[8] "Banda" is a Swahili name for the house types with rectangular shape, single bank system without a corridor accessed directly from outside.

such as creating a basement under the building's foundation plinth and using stilts/columns, were scantly recognised by most local artisans regardless of being the effective flood-resilient/adaptive measures. This finding is because such measures are complex and involve sophisticated construction techniques that require professional knowledge proficiency and huge costs. As such, they are less applied in low-income structures such as those in the Msasani Bonde la Mpunga settlement.

The study concludes that local artisans' knowledge on flood-resilient and adaptive measures in flood-prone Msasani Bonde la Mpunga, especially of complex/sophisticated engineering construction techniques, is relatively low. Most importantly, the study found that local artisans possess valuable knowledge and capacities in the form of local (informal) knowledge to facilitate many urban poor households to reduce hazards and disasters, notably those related to floods. For complex/sophisticated construction techniques, the study establishes that house owners' income limitations constrain local artisans' knowledge that helps to address the impact of floods. As such, artisans rarely get opportunities to put into practice some of their knowledge on issues, such as flood-resilient material choices and freedom of applying diverse construction techniques to increase building resilience to floods. This situation is also attributed to the lack of modern scientific knowledge and technology to enhance flood resilience and adaptation of buildings. It can also be concluded that local artisans and professional practitioners can benefit from each one's knowledge, especially the local artisan's tacit knowledge, if considered in flood disaster incidences. Thus, experiential knowledge of local artisans and communities is a crucial empowerment instrument that makes a difference in making flood-resilient/adaptive buildings in flood-prone informal settlements.

Despite the fact that the local artisans had quite satisfactory tacit and engineering knowledge about flood resilient and adaptive measures of buildings in Msasani Bonde la Mpunga, this article concludes that such knowledge is sometime hard to implement. This is especially because most households in the area are low-income earners. This observation suggests that, despite this knowledge dissemination among local artisans, realising flood-resilient and adaptive buildings in settlements with low-income households may take time. However, it is hard to ignore local artisans' knowledge and efforts to increase flood resilience and adaptations of buildings in such areas. This is because building houses in flood-prone areas entails taking into consideration various factors, including climate change impacts, informal settlement development and rapid urban population growth.

5.2. Recommendations

Local artisans working with local communities need to practice and widen their tacit knowledge to increase flood resilience and adaptation of buildings to ensure sustainable future flood prevention, mitigation, preparedness, response, and recovery. This observation can be achieved through demonstrating housing improvements by instituting training about flood resilience and adaptation of houses for local artisans, sensitising the populations and receiving responses from the local people in flood-prone informal settlements areas. Having in place the formal mechanisms, such as VETA colleges and professional persons (architects, engineers and technicians) to develop the capacity of local artisans, would be an essential step towards more effective and sustainable interventions to the impacts of risks in the flood-prone informal settlements in the city of Dar es Salaam. The article further recommends that practitioners working to manage floods in flood-prone informal settlements should consider integrating or blending their knowledge with the one acquired by the local artisans and communities to achieve hybrid flood resilient/adaptive measures. The reason is that local artisans have relevant local knowledge worth adopting and integrating with the formally acquired knowledge to increase flood resilience and adapt buildings in flood-prone areas. It is also worth suggesting that practitioners managing flood-prone areas require integrating modern scientific knowledge with local artisans' knowledge to make flood-resilience and adaptation of buildings interventions more effective. The study emphasises that it is critical to document indigenous/tacit knowledge on flood-resilient construction and adaptations of buildings of the local artisans from various local communities since knowledge tend to vary. This suggestion will contribute to recognising the local artisans' knowledge of flood-resilient measures that can be improved and reciprocated in other communities living in flood-risk areas. Such knowledge is worth learning and documenting because such flood measures can be applied even in the non-flood-prone areas.

Given the importance of the local artisans in enhancing community resilience in flood-prone areas, their knowledge (mostly tacit/indigenous) should be linked with the National Disaster Management initiatives and activities related to low-income housing construction. Notably, the indigenous knowledge

and construction skills the local artisans use to enhance flood resilience and adaptive buildings are critical areas requiring further research to underscore the potential of available skills and knowledge to help improve the exacerbating challenges of buildings constructed in flood-prone settlements. This study's findings may only be generalised to other areas in Dar es Salaam City or other places with a related context.

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