Yemen

# CCCM IDP Site Flood Hazard Exposure Analysis

## IDP Sites in Marib Governorate - Report

May 2024


REACH Informing more effective humanitarian action

CCCM CLUSTER
SUPPORTING DISPLACED COMMUNITIES

Cover photo credit: IOM, 2024

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# INTRODUCTION & RATIONALE

## INTRODUCTION

The outbreak of violence in Yemen in 2015 has resulted in an estimated total of 4.5 million internally displaced persons (IDPs) with more than half of total displacements occurring during the onset of the crisis that year.[1] The protracted nature of Yemen's IDP crisis is exemplified by the fact that as of March 2024, approximately 1.6 million IDPs were living across 2,284 displacement hosting sites in Yemen – primarily within Al-Hodeidah, Hajjah, Marib and Taiz governorates.[2] According to the 2024 Humanitarian Needs Overview (HNO), this corresponds to 4.5% of Yemen's total population residing within sites 'enduring extremely harsh conditions without viable alternatives.'[3]

One of the main underlying causes of these harsh conditions is the persistent and widespread threat of flooding to IDPs residing in hosting sites across Yemen. As a result of torrential rains in Yemen, flash floods are a recurrent hazard with destructive consequences which exacerbate the ongoing severe humanitarian needs in the country. Previous flood incidents have resulted in instances of multiple displacements, damage to site infrastructure and shelters, injuries and even deaths. Moreover, flooding incidents also drive the spread of water-borne diseases, whilst negatively impacting food security & livelihoods by harming agricultural potential and yields in addition to livestock. This widespread and persistent risk of flooding is reflected in the Camp Coordination & Camp Management (CCCM) Cluster's Flood Incident Report listing 893 flooding events that occurred and were reported between June 2021 and January 2024.[4]

Marib is amongst the governorates in Yemen with a particularly heightened susceptibility to flooding. For instance, in the 2024 REACH National IDP Site Flood Hazard Analysis, 80 IDP sites in Marib were classified as having a 'Critical' or 'High' flood hazard susceptibility (3rd highest governorate), corresponding to 34% of its IDP sites.[5] Furthermore, in the latest Site Monitoring Tool (SMT) Round 1 (R1) 2024 dataset covering January-February 2024, 7 flood incidents were reported across Government of Yemen (GoY) areas, with all cases being derived from 6 sites in Marib governorate.[6]

This report will outline the methodology utilised for this analysis alongside the limitations. The methodology section is followed by the key findings based on the 'Flood Depth' and 'Flood Hazard' maps produced per assessed site, which will be further cross-analysed with CCCM Flood Incident Report and REACH Site Monitoring Tool (SMT) data. The report concludes with a summary of the analysis and recommendations for next steps.

1. IOM (2019) Yemen Area Assessment Round 37, March 2019
2. CCCM Cluster Yemen, IDP Sites Master List (March 2024)
3. Humanitarian Needs Overview (HNO) 2024, Yemen
4. 2024 REACH National Flood Hazard Analysis, Site Severity Scoring Dataset (April 2024)
5. Ibid.
6. Site Monitoring Tool (SMT) 2024 Round 1 Dataset (January - February 2024)

## RATIONALE

Amidst this backdrop, REACH utilized high-resolution 2.5m Digital Elevation Model (DEM) Hydrologic Engineering Center's River Analysis System (HEC-RAS) imagery in Marib to map flood hazard across 5 IDP sites in Marib. Primarily, this analysis serves to build on the 2024 National Flood Hazard Analysis findings by providing a localized analysis of Al-Jufaineh (largest IDP site in Yemen) in addition to Al-Sowayda, Saylat-Al-Mil, Saylat-Alrumalyah and Masna'a Adhban. All of these sites received 'High' flood hazard classifications in REACH's 2024 analysis. This analysis aims to support programmatic and operational interventions across the assessed sites and provide guidance for future flood preparedness, mitigation, and anticipatory action activities. This is critical given the declining funding for the Yemen response in addition to the protracted nature of its displacement crisis, and increased threat off flooding due to climate change.

Image 1: Al-Sowayda IDP Site (provided by partner during May 2024). Source: Human Access

# METHODOLOGY

## Background

Since 2019, REACH has been working on flooding in Yemen, starting with Flood Susceptibility Mapping and the 2020 National IDP Site Flood Hazard Analysis. Since then, REACH, in collaboration with the CCCM and Shelter Cluster's and in coordination with CCCM partners have been involved in the process of selecting sites based on their knowledge of the exposure, vulnerability and risk of flooding in the sites for dedicated, localised, flood hazard analysis.

The topography of Marib is diverse, and characterised by mountainous areas in the west, large swathes of desert and low-lying plain regions. Based on historical flooding data from the CCCM Flood Incident Report and the REACH Site Monitoring Tool, flooding has been a recurrent issue across IDP sites in Marib governorate. For instance, 80 sites were categorised as 'Critical' or 'High' Hazard in the 2024 REACH National Flood Hazard Analysis, corresponding to 34% of sites in Marib.[7]

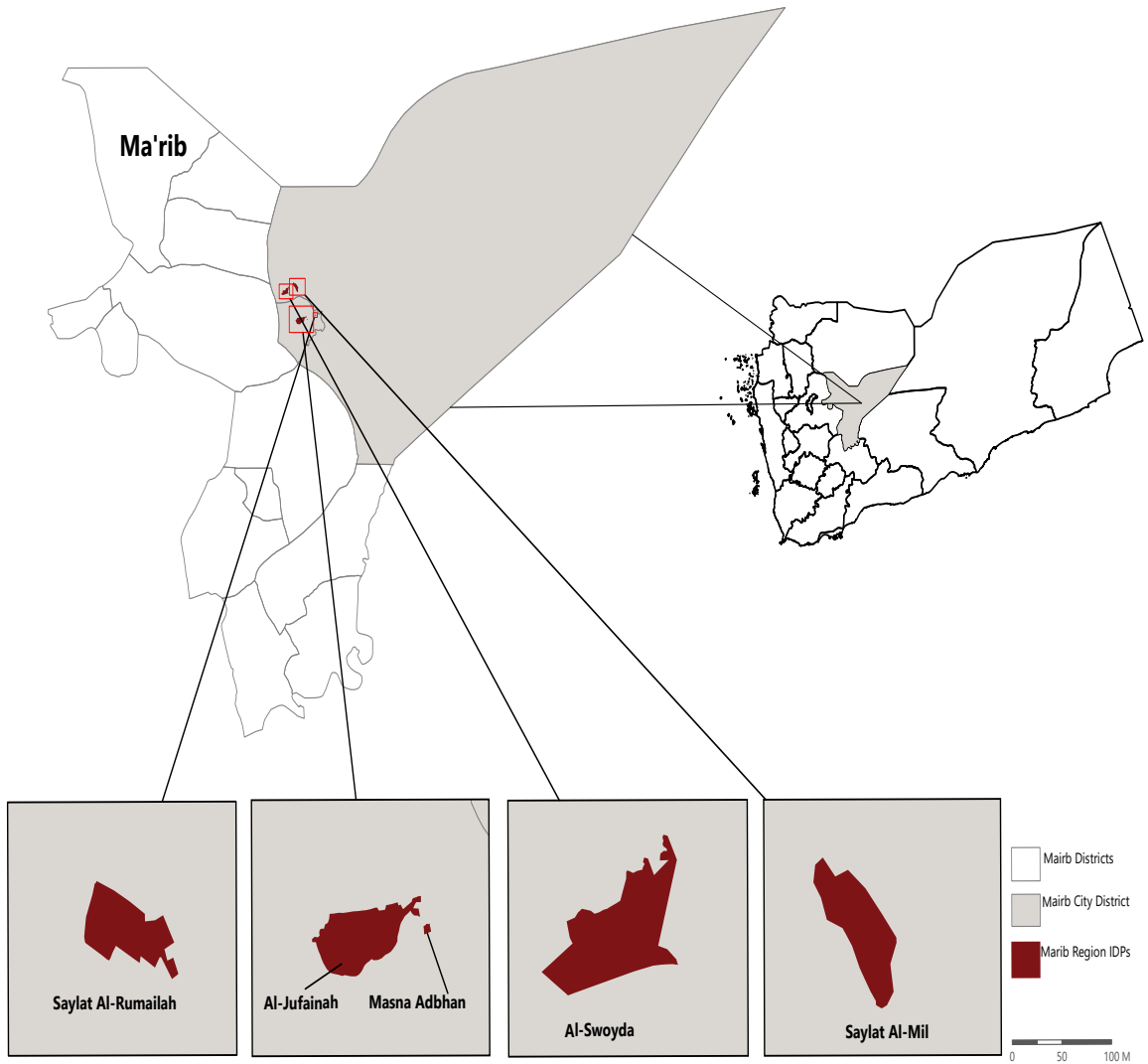
After consultations with the CCCM and Shelter Clusters, the selection of 5 IDP sites was confirmed in October 2023 after discussions with Human Access and IOM (the relevant CCCM partners). Notably, these IDP sites included Al-Jufaineh, the largest IDP site in Yemen. Al-Jufaineh has a total population of 74,406 site residents as of March 2024, corresponding to 22% of the overall in-camp population in Marib governorate.[8] Additionally, Al-Soweyda, Saylat-Almil, Masna'a Adhban and Saylat Alrumayla were selected. Collectively, these assessed sites comprise 28% of the total IDP population in Marib governorate.[9] The selected shortlist of sites was reaffirmed by the publication of the REACH 2024 National Flood Hazard analysis in April 2024, where each of the five assessed sites received a 'High' flood hazard classification.[10]

## HEC-RAS Floods Modelling

A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment area in Marib governorate. The approach allows an understanding of flood hazards on a catchment-wide scale and identification of areas prone to flood risk. This method of 2D flood modelling is also referred to as a Rapid Flood Hazard Assessment (RFHA). As a result of the precipitation values and simulation parameters used, the model attempts to reproduce the conditions of storms that would cause actual flash flood events.

Furthermore, consultation calls with site engineers and field teams at Human Access and IOM respectively were conducted in order to obtain information on existing site infrastructure or flood preparedness measures which may alter the flow of water during heavy rain events. Where possible, these were incorporated into the final results displayed on each site's flood depth and flood hazard maps.

## Coverage Map - Marib Watershed




7. 2024 REACH National Flood Hazard Analysis, Site Severity Scoring Dataset (April 2024)
8. CCCM Cluster Yemen, IDP Sites Master List (March 2024)
9. Ibid.
10. 2024 REACH National Flood Hazard Analysis, Site Severity Scoring Dataset (April 2024)

# METHODOLOGY

## Methodology Overview

REACH requested UNOSAT to conduct the HEC-RAS analysis in the selected watershed in Marib governorate, which was later shared by UNOSAT in November 2023. Between February-March 2024, REACH conducted shelter mapping for the shortlisted sites by utilising ArcGIS machine learning algorithms. Meanwhile, utilising a collaborative approach, REACH and CCCM Partners (Human Access & IOM) drew site boundaries of the selected sites. In March 2024, REACH met with IOM to share and obtain feedback/field validation on the maps, with IOM later agreeing to provide REACH with updated files on additional site infrastructure in Al-Jufaineh to incorporate into REACH models.

REACH overlayed the results of this UNOSAT HEC-RAS analysis with landuse, shelters, points of interest, and roads to classify each with flood hazard and flood depth scores. Preliminary results were shared with Human Access and IOM to obtain field validation prior to publication.

Flood hazard scores per site were obtained by multiplying the modelled flood depth and velocity. A higher velocity corresponds to increased damage, whilst a higher depth to a deeper flood area. This classification of flood hazard in this analysis is based on the simplified approach presented by the US Federal Emergency Management Agency in their guidance on Flood Depth and Analysis Grids.[11] This approach separates hazard severity into 5 classes from low to extreme (see Table 1). In addition to being a sub-indicator for flood hazard classifications, 'Flood Depth' also constitutes a useful indicator for determining flood exposure, due to representing water flow extents and the static accumulation of water, which can also be the cause of flood risk. The severity of flood water depth can be classified into 5 flood hazard categories from 'very low' to 'extreme', based on criteria formulated by the Japanese Ministry of Land Infrastructure, where each hazard category is associated with the relative risk of damage, threat to human safety, and the possibility of evacuation.[12,13] Table 1 below visualizes the hazard and depth severity classifications utilised for this analysis. For the purpose of this analysis, a 'Flood Depth' and 'Flood Hazard' map was produced for each of the assessed sites, and overlayed with site shelters and critical infrastructure (when available) in order to classify the number of shelters and/or key site infrastructure within each hazard severity category. In the key findings per site below, this is considered alongside data available from the REACH 2024 National IDP Site Hazard Analysis, the CCCM Flood Incident Report and the REACH SMT tool.

| Hazard severity category | Depth x Velocity (m²/s) | Depth severity category | Depth (m) |
|---|---|---|---|
| Low | < 0.2 | Very low | < 0.5 |
| Medium | 0.2 - 0.5 | Low | 0.5 - 1 |
| High | 0.5 - 1.5 | Medium | 1 - 2 |
| Very High | 1.5 - 2.5 | High | 2 - 5 |
| Extreme | > 2.5 | Extreme | > 5 |

11. FEMA (2018), Guidance for Flood Risk Analysis and Mapping
12. Quiroga, V.M; Kurea, S.; Udoa, K.; Manoa, A. Application of 2D numerical simulation for the analysis of the February 2014 Bolivian Amazonia flood: Application of the new HEC-RAS version 5. Ribagua 2016, 3, 25–33.
13. https://bit.ly/FloodHazardMappinginJapan

## Technical Limitations

There are several technical limitations of the HEC-RAS modelling to consider, all of which have an impact on the results and diminish the model's ability to provide precise flood hazard and flood depth extents per assessed site. As this analysis was conducted remotely, the results of this analysis need to be calibrated and validated based on field inspections within the assessed sites. This limitation was mitigated by regular consultations with CCCM Partners (Human Access & IOM), in addition to their review of this report. Therefore, all results presented in this report should be considered indicative and should be used primarily to provide an indication of the susceptible floodplain locations within the assessed sites.

Furthermore, the following limitations should also be considered when interpreting the model's outputs in order to inform programmatic and operational planning.

- Many of the engineering structures present in the sites that can mitigate flood hazard were shared with REACH after the completion of the HEC-RAS analysis by UNOSAT, and therefore were not included in the models. This may have altered the final output.
-The DEM terrain dataset was not validated and relies on satellite data with a vertical accuracy of 5 meters or less.
- The model results are neither calibrated nor validated to a field observation.
- The infiltration losses are estimated with the SCS-CN method from a coarse hydrological soil group dataset and a land cover dataset that is not field validated.

- Other obstacles to flow (except the bridge and buildings) are not included in the model.
- Rainfall was applied as a one-time series to the 2D domain, without any spatial variability.
- Due to the lack of reliable and up-to-date precipitation data from weather stations in Yemen, this analysis relied on extracting precipitation data from Saudi Arabia as a substitute.
- More data was available regarding site infrastructure for Al-Jufaineh than the other assessed sites, which facilitated a more detailed analysis for Al-Jufaineh, and the potential omission of important site infrastructure (both in terms of site services and flood preparedness measures) from this analysis.

# KEY FINDINGS PER SITE

## Al-Jufaineh

### Site background, historical flooding & vulnerability

Al-Jufaineh is the largest IDP site in Yemen, with its total population of 74,406 residents across 14,480 HHs, corresponding to 22% of the entire in-camp population in Marib governorate. According to 2024 SMT R1 data, Al-Jufaineh is a self-settled site in an urban area located on private land. The sites' location on private land in addition to SMT 2024 R1 data indicating that only a verbal tenancy agreement is in place may exacerbate difficulties in obtaining approval to implement flood preparedness measures and risks forced eviction.

Al-Jufaineh reported flooding in the CCCM Flood Incident Report in both July 2022 and March 2023 respectively. No injuries or deaths were reported during either flood, but the former resulted in damage to 233 shelters, 255 food kits as well as the site's culverts. The consequences of future flooding events in Al-Jufaineh may be further exacerbated by the shelter types located within the site. While SMT 2024 R1 data indicated that little under half of site shelters were reportedly transitional shelters (49%), the diversity of the site was exemplified by the presence of unfinished buildings (5%), makeshift shelters (5%) and tents (3%) all of which may have pose heightened vulnerabilities during a flooding event. Despite these shelter typologies, Al-Jufaineh reported no gaps with regard to site maintenance, security and safety in SMT 2024 R1 data. Although, Al-Jufaineh cited fire as a major safety threat in the site, with 6 fire incidents reportedly occuring during January-February 2024 (SMT R1 2024).

Al-Jufaineh contains some pre-existing engineering structures that constitute flood preparedness measures. For example, at the northernmost border of the site, directly south of the main highway lies an earthen embankment. Furthermore, the map shows that several culverts have been built along the eastern side of the projected flood path from the modelling, which could serve to mitigate flood risks. However, this series of culverts does not extend along the entire projected flood path route with gaps in the western portions of the site along the borders of areas 'S6' and 'S10'. According to IOM partners, in 2022 the site experienced a collapse of a gabion wall during extensive flooding.

12% of shelters in Al-Jufaineh were reportedly in need of rehabilitation as of SMT R1 (February 2024).

**Evidence of preparedness measures**

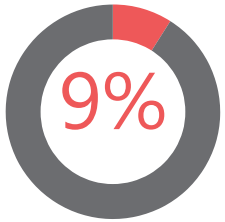
The primary flood path in the site runs along its southern perimeter from the eastern side, before cutting into the site boundaries and dividing area 'S10' where 1376 HHs reside from the remainder of the site. Therefore, a flooding event in Al-Jufaineh poses the risk of separating area S10 from the remainder of the site due to the projected flood path cutting across the two major roads out of the area.

This would potentially inhibit access to key services in the site located within other areas for residents of 'S10', who constitute 9% of site HHs (n=1376). For example, while area 'S10' contains a health clinic, it does not contain a hospital or a pharmacy. The only hospital in the site is located within the area 'S5'. Moreover, the two accessible waste disposal points accessible from area 'S10' lie directly in the projected flood path.

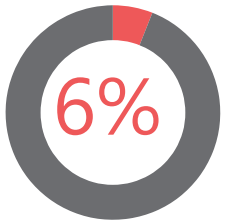
In terms of critical site infrastructure, the main entrance to the site was identified as having a 'high risk' of flood hazard, which could have negative consequences on the ability of CCCM Partners to respond to flooding events whilst posing safety risks for site inhabitants.

The map also indicates that there are large portions of rangeland located directly outside the IDP site boundaries suitable for raising livestock, but this rangeland availability is limited within the site boundaries. Notably, SMT R1 2024 data covering January-February 2024 found that Al-Jufaineh did not report home-grown food as a primary source of food, which was reaffirmed by the absence of agricultural land visible in the Al-Jufaineh flood maps.

## Key Findings




of shelters in Al-Jufaineh site were categorised as 'High Hazard' according to flood hazard modelling (n=1375)




of shelters in Al-Jufaineh site were categorised as 'High Hazard' according to the flood hazard modelling in addition to 'High Risk' from flood depth.

Image 2: Al-Jufaineh IDP Site (provided by partner during May 2024). Source: IOM

# AL-JUFAINAH - Flood Depth Model Map

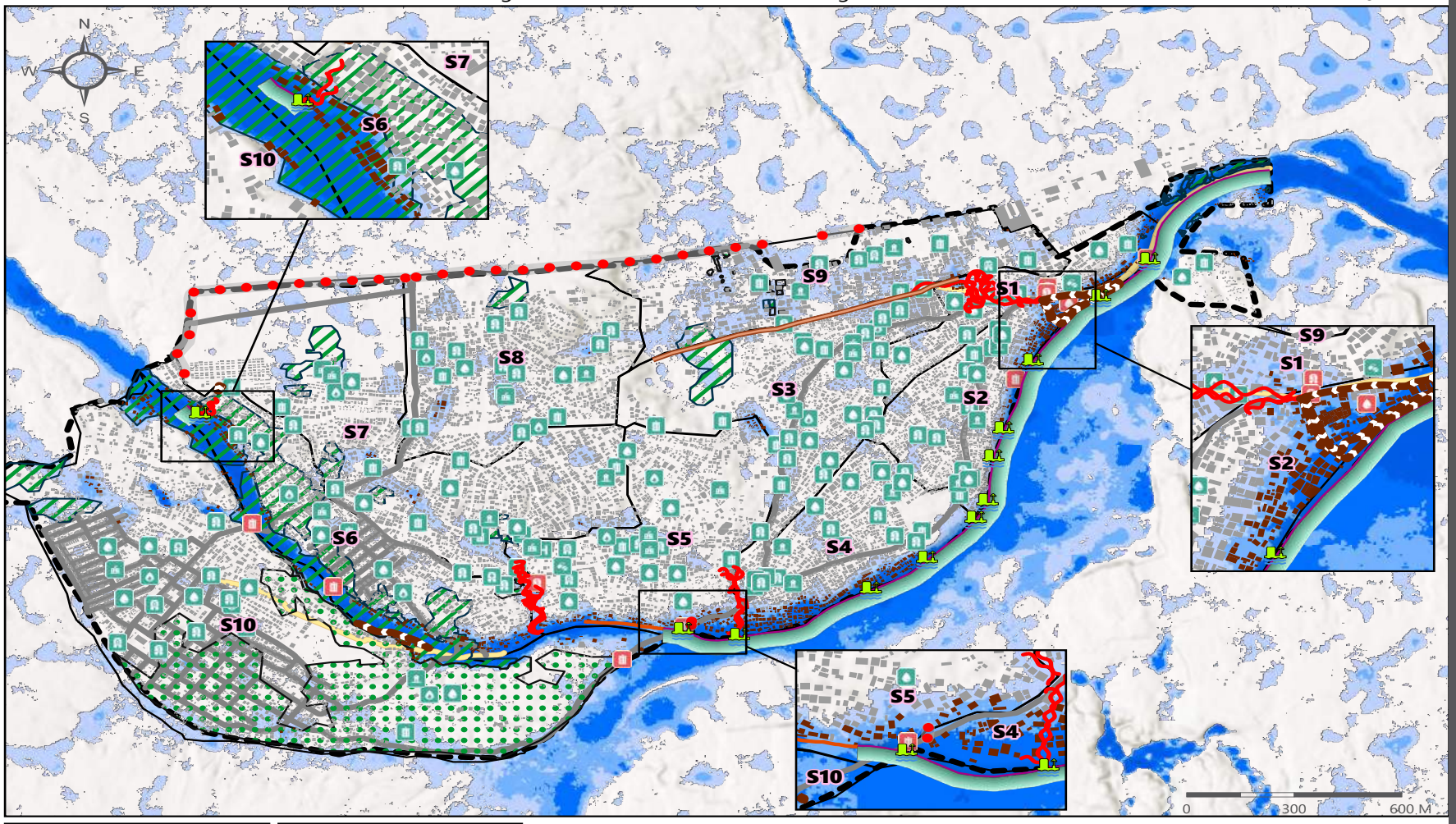
## Yemen - Marib - Al-Jufaineh Hazard

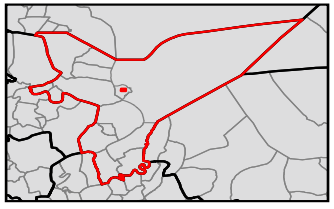
***Flood Depth 2024***

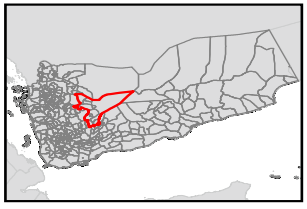
**962** Affected Buildings

**11** Affected Public Buildings

**Production Date : 30 May 2024**





Boundaries

Al-Jufaineh Hazard Sectors

**Al-Jufaineh Agricultural**

Affected Agricultural land

Not Affected Agricultural land

**Shelters Flood Depth**

Affected Sites

Not Affected Sites

**Roads**

Affected Roads

Not Affected Roads

**IOM Infrastructure**

Culverts

Masonry Pavement

Earthen Barrier

Earthen Embankment

Flood Risk Path

Gabion Wall

Internal Drainage

Retaining Wall

**Landmarks**

Affected Landmark

Not Affected Landmark

Waste Point

Hospital

Clinic, Medical Office

Pharmacy

Water Source, Water Point

Community Center

Fire Point

Grocery Store

Mosque

School

Hotel

**Modelled Depth Hazard (m)**

< 0.5

0.51 - 1

1.01 - 2

2.01 - 5

> 5

A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Sowayda IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation.

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodDepth_Aljufaineh_30May2024_A4

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# AL-JUFAINAH - Flood Hazard Model Map

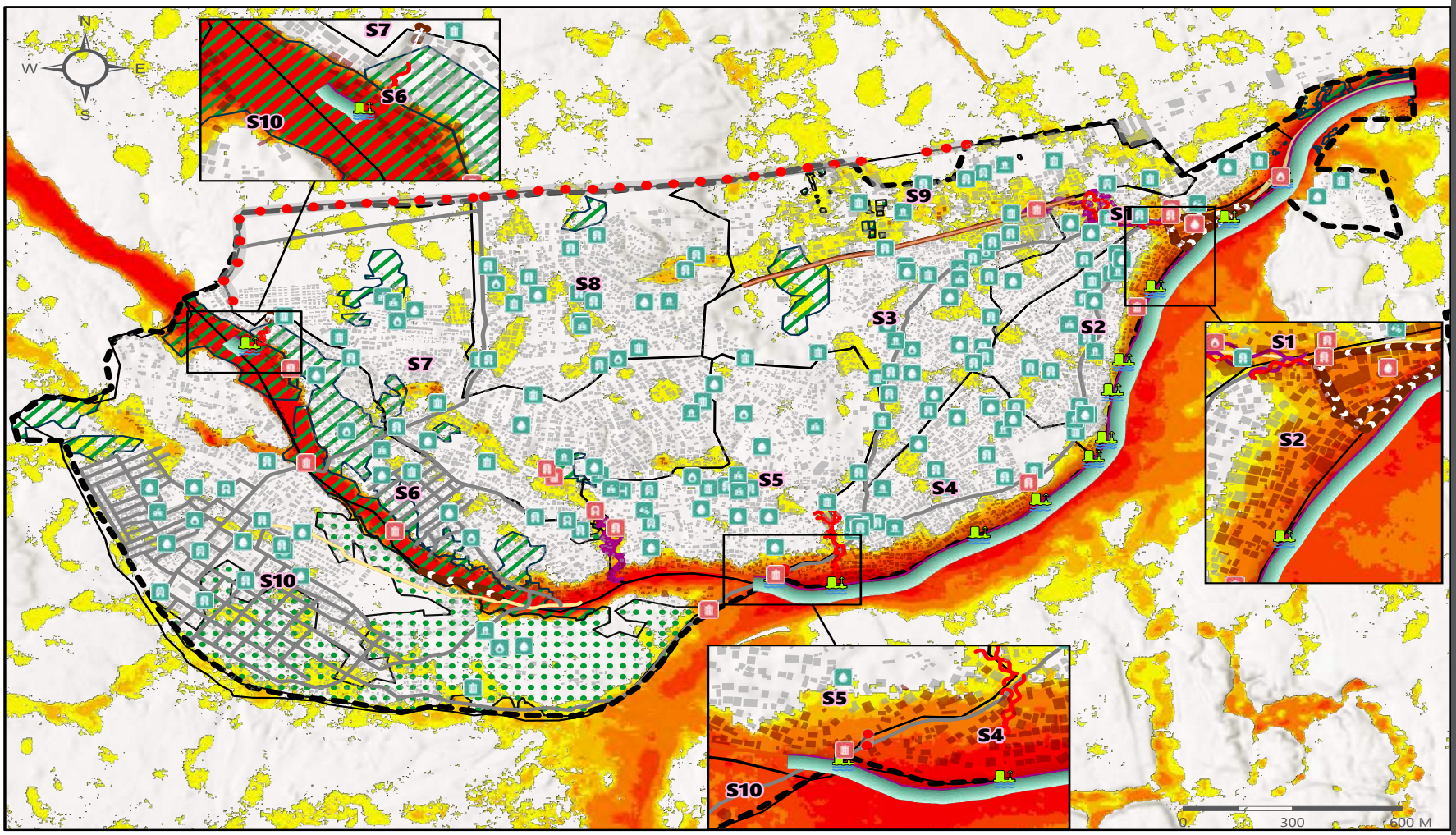
## Yemen - Marib - Al-Jufaineh Hazard

***Flood Hazard 2024***

**1,375**
Affected Buildings

**18**
Affected Public Buildings

**Production Date : 30 May 2024**




- Boundaries
- Al-Jufaineh Hazard Sectors

**Al-Jufaineh Agricultural**
- Affected Agricultural land
- Not Affected Agricultural land

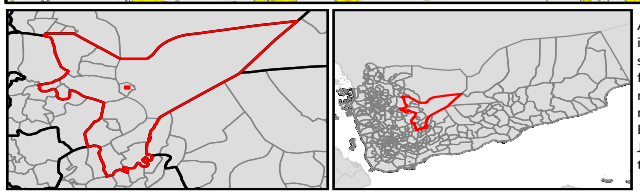
**Shelters Flood Depth**
- Affected Sites
- Not Affected Sites

**Roads**
- Affected Roads
- Not Affected Roads

**IOM Infrastructure**
- Culverts
- Masonry Pavement
- Earthen Barrier
- Earthen Embankment
- Flood Risk Path
- Gabion Wall
- Internal Drainage
- Retaining Wall

**Landmarks**
- Affected Landmark
- Not Affected Landmark
- Waste Point
- Hospital
- Clinic, Medical Office
- Pharmacy
- Water Source, Water Point
- Community Center
- Fire Point
- Grocery Store
- Mosque
- School
- Hotel

**Modelled Flood Hazard (m)**
- <= 0.2
- 0.21-0.50
- 0.5-1.5
- 1.51-2.5
- >2.5



A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Jufaineh IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodHazard_Aljufaineh_30May2024_A4

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# KEY FINDINGS

## Saylat-Al-Mil

### Site background, historical flooding & vulnerability

Saylat-Al-Mil has a population of 4055 site residents divided across 675 HHs, making it the 7th largest site in Marib governorate by population. Unlike the other assessed sites which are all self-settled, Saylat-Al-Mil is a planned camp. According to SMT 2024 R1, the site is located in a rural location with private land ownership and a verbal tenancy agreement, a combination that may make site interventions more difficult.

Notably, this site reported two instances of flood occurrences in SMT R1 2024 data covering January-February 2024, corresponding to 29% of all floods reported in GoY areas for the reporting period. According to the CCCM Flood Incident Report, the site also reported one prior flooding incident during March 2023, which reportedly resulted in zero injuries or deaths, but directly affected 133 HHs - corresponding to 20% of the site, in addition to partial damage to 144 shelters and total destruction of a further 11. Critically, in SMT R1 2024, Saylat-Al-Mil reported universal gaps in site maintenance services, which may further heighten the vulnerability of site residents to future flooding events.

Despite this history of flooding events, as of February 2024, flood committees were not reportedly present within the site. IOM site management focal points noted during SMT 2024 R1 data collection that they have "a plan to identify safe evacuation locations, establish an emergency committee, determine communication channels and evacuation routes, create flood defences, earth barriers and identify vulnerable areas on the site." These plans have not yet been implemented.

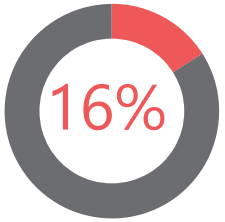
The vulnerability of Saylat-Al-Mil's residents to flooding may be further exacerbated by its shelters, which were primarily comprised of emergency shelters as of SMT R1 (February 2024), but also containing makeshift shelters (10%) and transitional shelters (7%). Moreover, it was also reported that three HHs live in open-air conditions, reflective of a critical vulnerability.

**24%** of shelters in Saylat-Al-Mil were reportedly in need of replacement as of SMT R1 (February 2024)

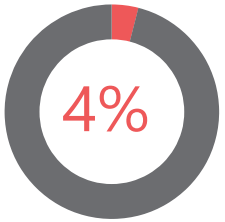
**Evidence of preparedness measures**

Unlike Al-Jufaineh, based on the critical infrastructure labelled on the flood hazard and depth maps there is little evidence of flood preparedness measures existing in Saylat-Al-Mil (there exists no earthen barriers, gabion walls or culverts to help with flood preparedness). Primarily, areas of high flood hazard are concentrated around areas 'S2' and 'S3. There also exists a stream of 'extreme' and 'high' flood hazards running along the southern perimeter of the site, which could impede access to the site during a flooding event. Critically, a large proportion of the sites mapped critical infrastructure falls within flood hazard zones.

## Key Findings




of shelters in Saylat-Al-Mil site were categorised as 'High Hazard' according to the flood hazard calculations.




of shelters in Saylat-Al-Mil site were classified with a 'High' depth severity, indicative of a heightened risk due to potential flood depth for these shelters.

Both (n=2) grocery stores mapped in Saylat-Al-Mil site were classified as being at 'High Risk' of flood hazards.

One out of three schools mapped in Saylat-Al-Mil site were classified as being at 'High Risk' of flood hazards.

# SAYLAT-ALMIL - Flood Depth Model Map

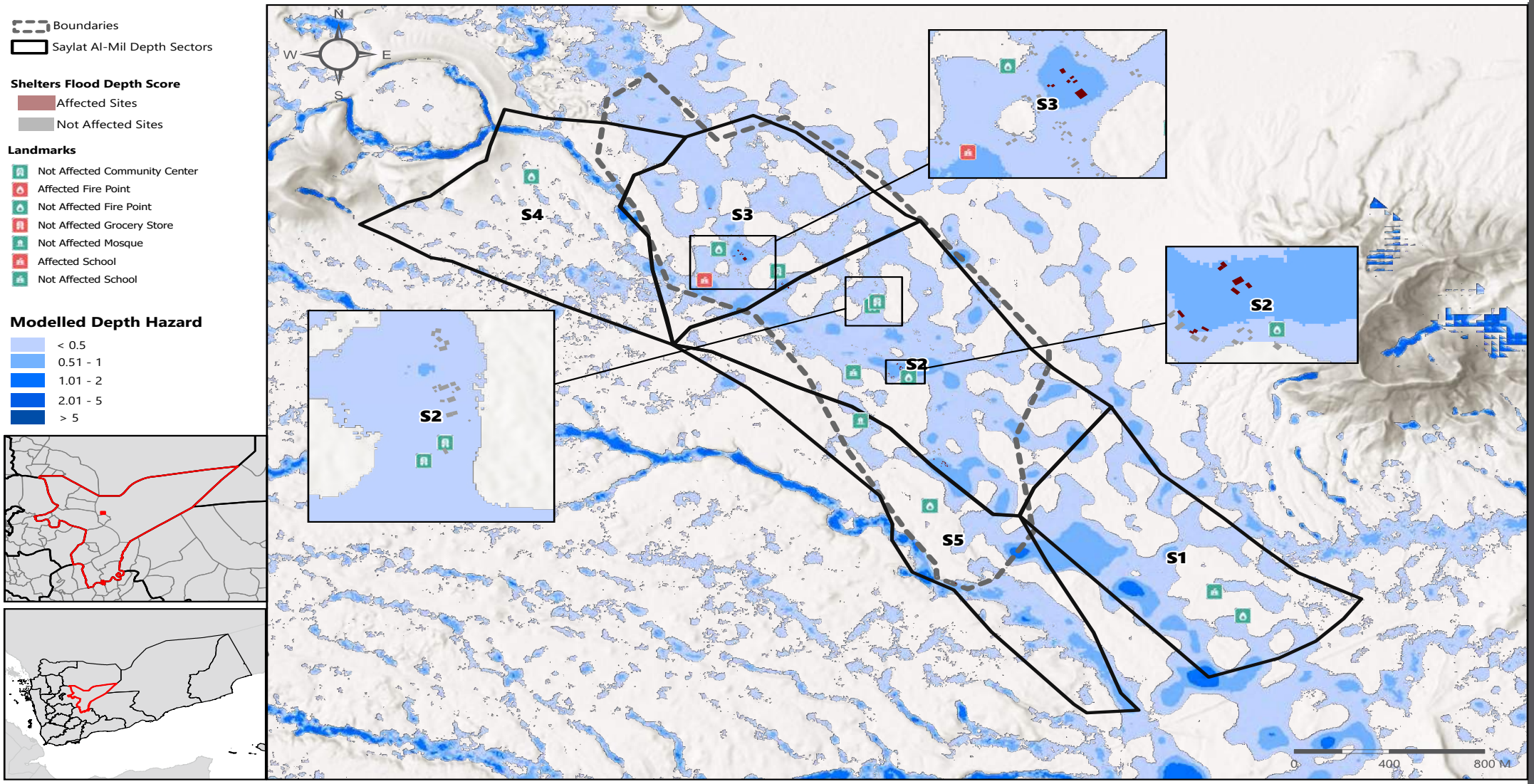
## Yemen - Marib - Saylat Al-Mil Depth

***Flood Depth 2024***

**33**
Affected Buildings

**1**
Affected Public Buildings

**Production Date : 30 May 2024**




A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Saylat Al-Mil IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI
ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodDepth_Saylat Al-Mil_30May2024_A4

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# SAYLAT-ALMIL - Flood Hazard Model Map

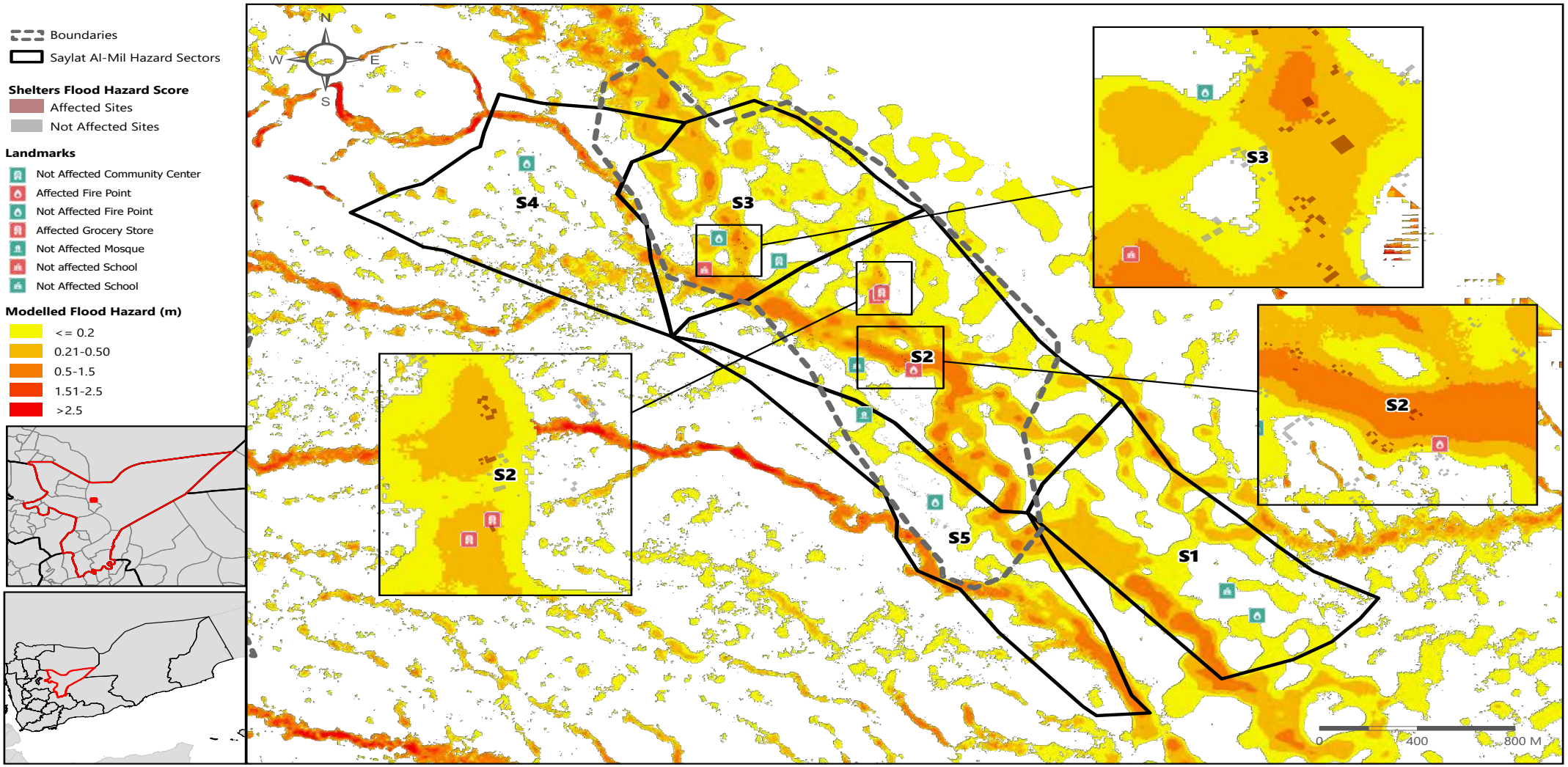
## Yemen - Marib - Saylat Al-Mil Hazard

*Flood Hazard 2024*

**128** Affected Buildings

**4** Affected Public Buildings

**Production Date : 30 May 2024**

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ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodHazard_Saylat Al-Mil_30May2024_A4

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## Saylat-Alrumayla

### Site background, historical flooding & vulnerability

Saylat-Alrumayla has a population of 1718 site residents divided across 337 HHs, making it the smallest IDP site covered by this analysis. According to SMT R1 2024, the site was self-settled, located in a rural location, is located on private lands and has a verbal tenancy agreement. The combination of an absence of a formal written tenancy agreement and private land ownership may contribute to making interventions in Saylat-Alrumayla site more difficult. Reflective of this, IOM partners reportedthat the landowner has previously rejected the implementation of site modifications to mitigate flood exposure.

According to the CCCM Flood Incident Report, one flooding incident was reported in Saylat-Alrumayla during March 2023, which resulted in the partial damage of 80 shelters - an alarming number in consideration of current population figures. Although, this flooding incident did not result in any injuries or deaths.

The shelters in Saylat-Alrumayla were primarily transitional shelters (49%) as of February 2024, but also included a significant number of makeshift shelters (26%) and tents (20%). This is critical considering that tents and makeshift shelters likely have a heightened risk to site residents during a flooding event than other types of shelters. These findings are particularly alarming when accounting for the fact that 92% of the shelters in the site were categorised as being at 'High Hazard'and 89% at 'High Risk' based on the projected flood depth. Hence, this may be indicative of the need for interventions targetting the improvement of shelters.

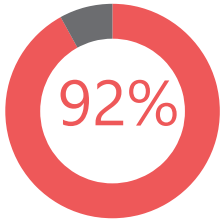
**36%** of shelters were reportedly in need of replacement or rehabilitation as of SMT R1 (February 2024), disaggregated into 18% requiring replacement (n=50) and 18% requiring rehabilitation (n=50).

**Evidence of preparedness measures**

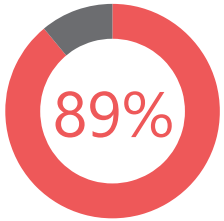
There is little evidence of flood preparedness measures existing in Saylat-Alrumayla, with the site reportedly lacking earthen barriers, gabbion walls or culverts to help with flood preparedness. Critically, the 'Flood Hazard' map indicated that large swathes of the site are subject to 'extreme' flood hazard, including areas with a high shelter density. This 'extreme' flood hazard classification renders Saylat-Alrumayla at relatively high flood hazard in comparison to the other assessed sites. This is particularly alarming in consideration of the fact that this site also has a relatively high proportion of inadequate shelters defined by need for replacement and/or rehabilitation, and the aforementioned absence of flood preparedness measures.

Furthermore, the main highway for the site was considered as 'High Risk', which poses a potential critical vulnerability impeding CCCM partners' ability to respond in a flooding event. Additionally, all water points and the mosque were considered at 'High Risk'.

## Key Findings

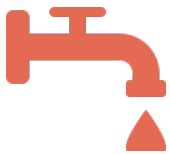



of shelters in Saylat-Alrumayla were categorised as 'High Hazard', indicative of widespread vulnerability.




of shelters in Saylat-Alrumayla site were classified with a 'High' depth severity, indicative of a heightened risk based on potential flood depth for the vast majority of the sites' shelters.

Crucially, the findings for Saylat-Alrumayla indicate almost universal risk to site shelters and far higher proportions of risk than the other assessed sites. Therefore, consultations should occur between the CCCM & Shelter Cluster's, IOM and other relevant CCCM partners to determine whether Saylat-Alrumayla is an unsuitable location to host IDPs, or whether the assessed risks can be mitigated by the implementation of preparedness, mitigation and anticipatory action measures.



100% (n=4) of the water points in Saylat-Alrumalya were classified with a 'High' risk of flooding - and three of these had a high severity for flood depth. Moreover, the sites' mosque, main road, fire points and water source were classified as being at 'High' risk of flooding. As for land, the sites' area containing agricultral crops was classified as being at 'High' risk of flooding, in addition to its rangeland.

Image 3: Shelter damaged during flooding in Saylat-Alrumayla. Source: IOM

# SAYLAT-ALRUMAYLA - Flood Hazard Model Map

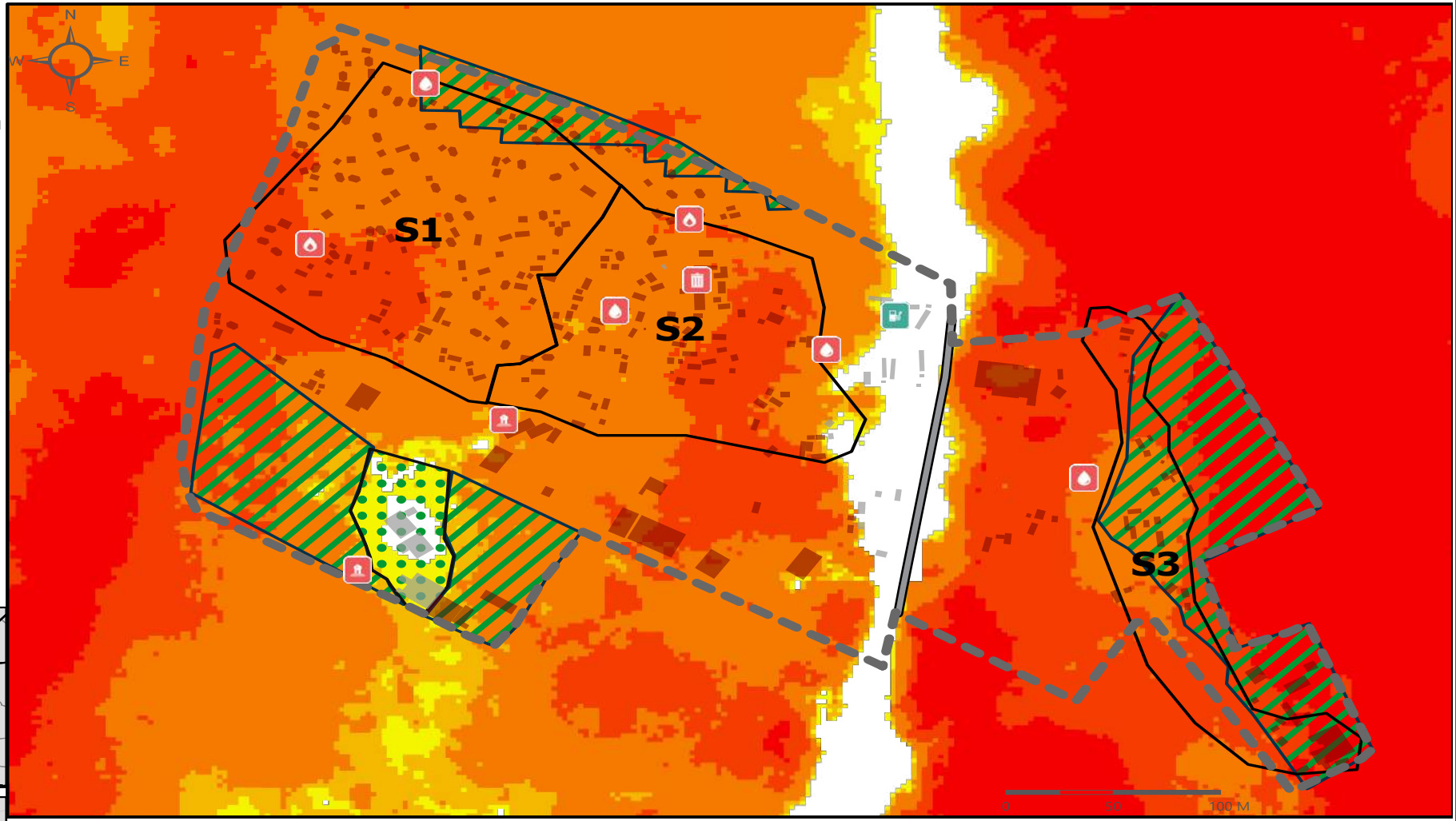
## Yemen - Marib - Saylat Al-Rumayla

*Flood Hazard 2024*

**330** Affected Buildings

**9** Affected Public Buildings

**Production Date : 30 May 2024**




Boundaries
AL-Rumayla Sectors

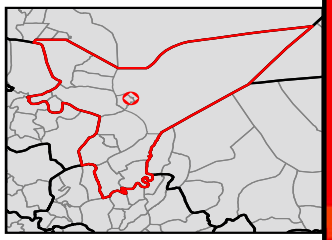
**AL-Rumayla Agricultural**
Affected Agricultural land
Not Affected Agricultural land

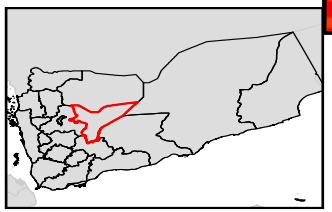
**Shelters Flood Hazard Score**
Affected Sites
Not Affected Sites

Affected Roads

**Landmarks**
Affected (WCP) Waste Point
Affected Fire Point
Not Affected Gas Company
Affected Mosque
Not Affected Mosque
Affected Water Point
Not Affected Water Point

**Modelled Flood Hazard (m)**
<= 0.2
0.21-0.50
0.5-1.5
1.51-2.5
>2.5





A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Rumalieh IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodHazard_Al-Rumileh_30May2024_A1

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# SAYLAT-ALRUMAYLA - Flood Depth Model Map

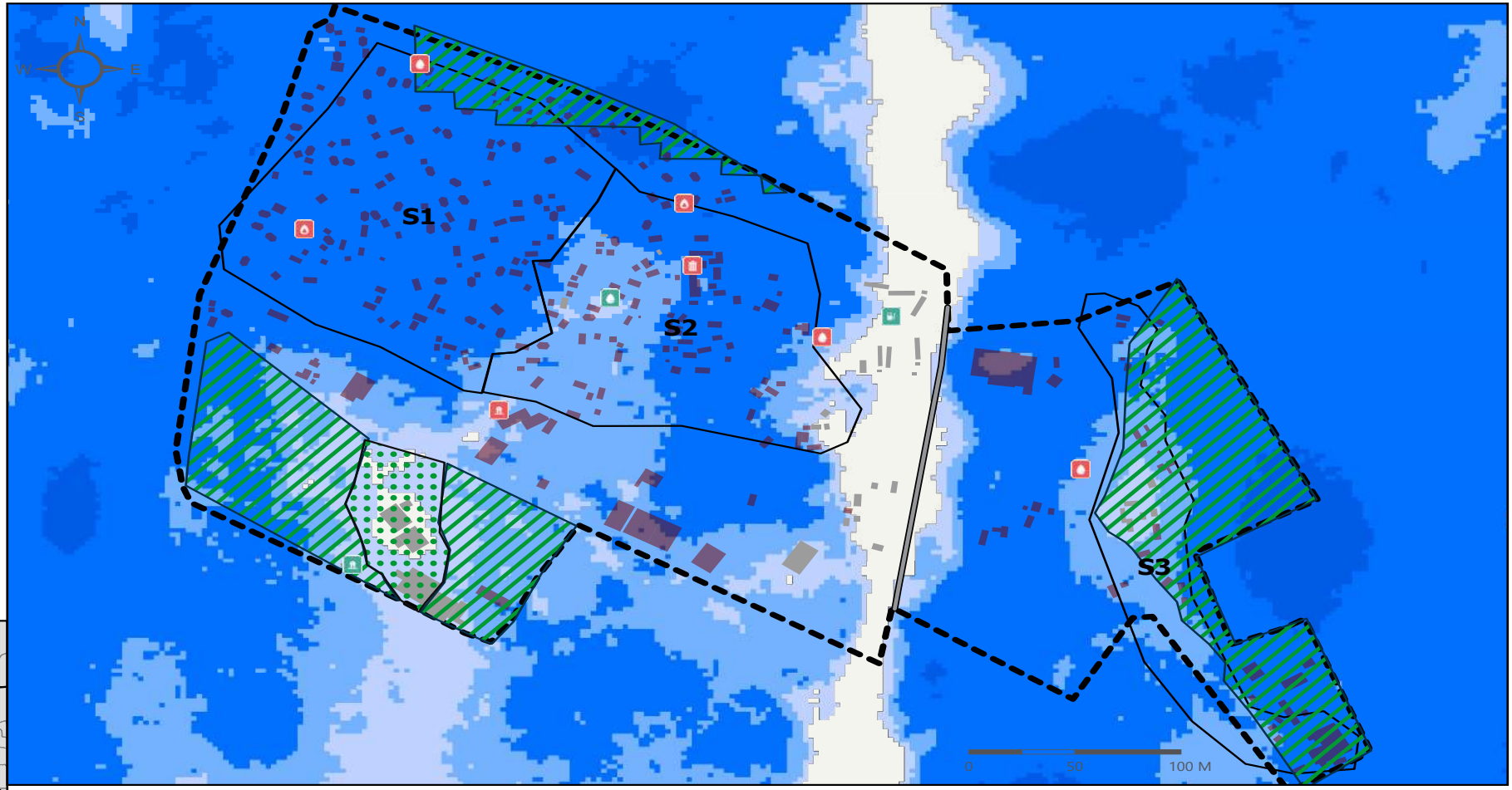
## Yemen - Marib - Saylat Al-Rumayla

***Flood Depth 2024***

**316**
Affected Buildings

**7**
Affected Public Buildings

**Production Date : 30 May 2024**



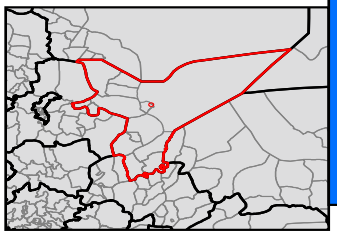

Boundaries
AL-Rumayla Sectors

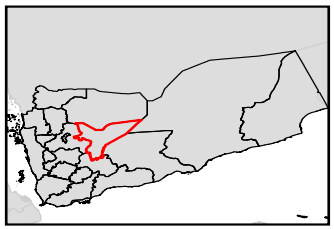
**AL-Rumayla Agricultural**
Affected Agricultural land
Not Affected Agricultural land

**Shelters Flood Depth**
Affected Sites
Not Affected Sites
Not Affected Road

**Landmarks**
Affected (WCP) Waste Point
Affected Fire Point
Not Affected Gas Company
Affected Mosque
Not Affected Mosque
Affected Water Point
Not Affected Water Point

**Modelled Depth Hazard (m)**
<=0.5
0.51 - 1
1.01 - 2
2.01 - 5
> 5





A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Rumalieh IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodDepth_SaylatAlrumayla_30May2024_A4

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## Masna'a Adhban

### Site background, historical flooding & vulnerability

Masna'a Adhban has a population of 3506 site residents divided across 705 HHs. Based on SMT 2024 R1 data, the site was self-settled, located in an urban area on private lands and lacks both a written and verbal tenancy agreement. Crucially, this complete absence of a tenancy agreement and location of the site on private lands may contribute to making flood preparedness, mitigation and anticipatory action interventions in the site more difficult. These difficulties are further accentuated by SMT 2024 R1 data which indicated that there is a lack of safety and security or disaster and risk reduction (DRR) service provision currently implemented in the site (February 2024).

According to the CCCM Flood Incident Report, the site previously experienced flooding during March 2023, which, while resulting in no injuries or deaths, partially destroyed 420 shelters - corresponding to 44% of the total existing shelters of the site as of SMT 2024 R1. According to IOM partners, a group of IDPs previously resided in a location next to the flood path, but this block has since been relocated onto higher lands. IOM partners also reported that floods are caused by heavy rains that fall within the IDP site, where it collects and causes damage in densely populated areas.

As of SMT 2024 R1, 36% of the shelters in the site were tents - which may exacerbate vulnerabilities in Masna'a Adhban to flooding events, given the lack of protection offered by these shelters in terms of flood defences.

**31%** of shelters were reportedly in need of repair or maintenance as of SMT R1 (February 2024).

**Evidence of preparedness measures**

An evaluation of the maps below for Masna'a Adhban reveal that the sites' flooding susceptibility is relatively low. Patches of 'Low' flood hazard risk exist on the eastern and northern borders of the site, with a small patch concentrated in the site amongst shelters. However, the severity of this flood risk was not high enough to trigger a 'High Hazard' classification for any of these shelters. To some extent, these results contradict the data available from the CCCM Flood Incident Report which contains historical examples of flooding events in the site which impacted site shelters.

**KEY FINDINGS**


of shelters in Masna'a Adhban areas were categorised as 'High Hazard' according to the flood hazard modelling.

While all site infrastructure and shelters were classified as 'Low' for both flood hazard and flood depth, agricultural land in the site that is utilised for crop production was provided with a 'High' classification for both flood hazard and flood depth. This indicated that future flooding events may have an adverse effect on food security and livelihood generating activities.

# MASNA'A ADHBAN - Flood Depth Model Map

## Yemen - Marib - Masna'a Adhban

***Flood Depth 2024***

**0** Affected Buildings

**0** Affected Public Buildings

**Production Date : 30 May 2024**

Boundaries

Masna'a Adhban Sectors

**Shelters Flood Depth Score**

Affected Sites

Not Affected Sites

**Landmarks**

Not Affected Mosque

Not Affected Water Source

Fire Point, Low Risk

**Modelled Depth Hazard (m)**

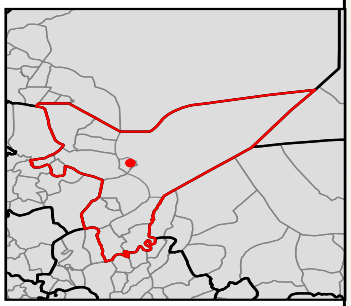
< 0.5

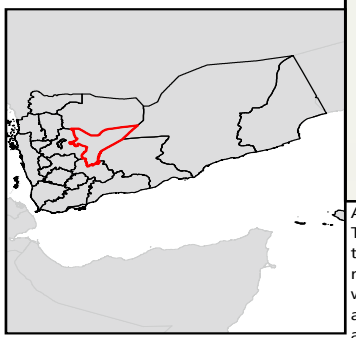
0.51 - 1

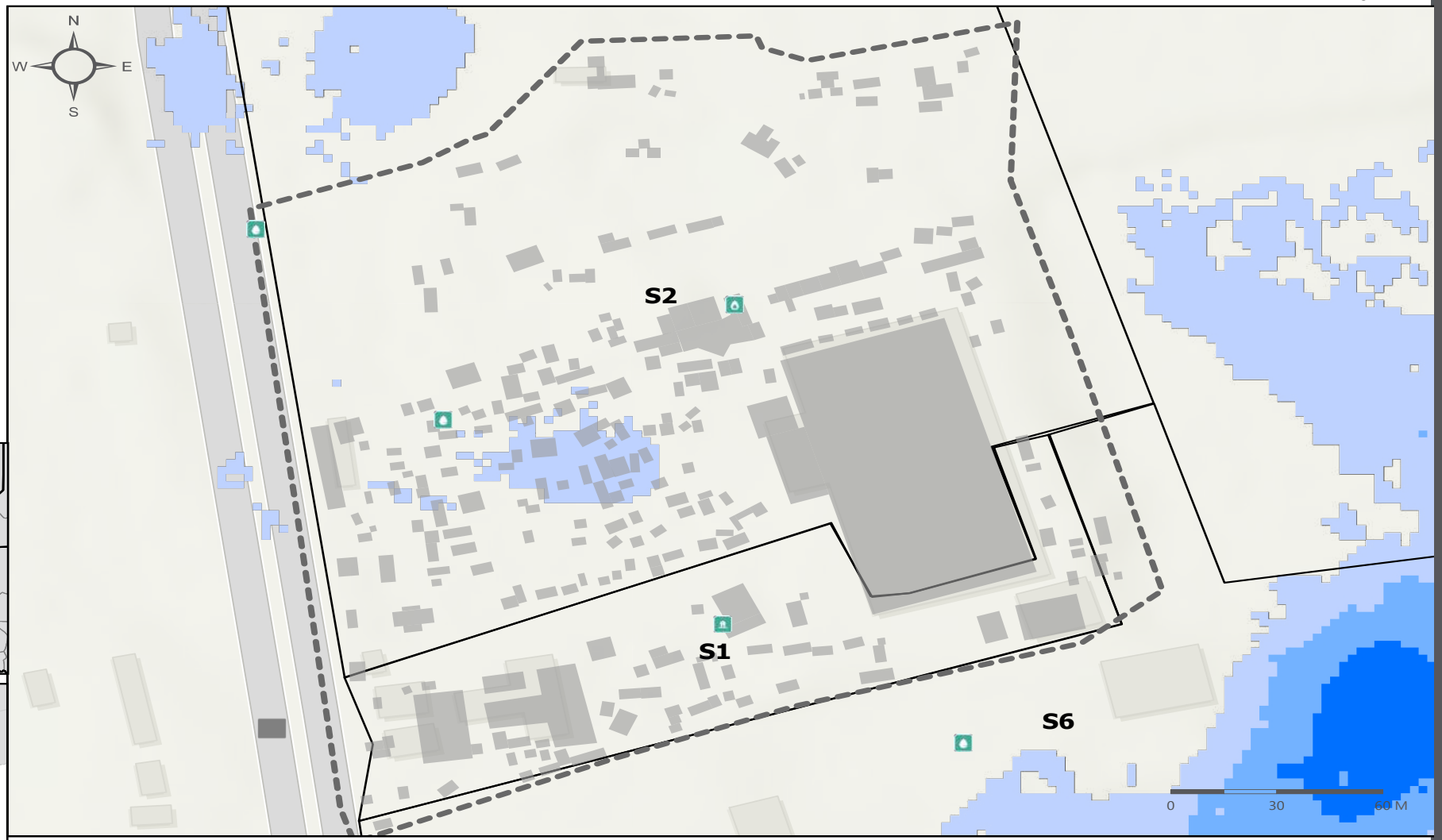
1.01 - 2

2.01 - 5

> 5








A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Masnaa Adhban IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodDepth_MasnaaAdhban_30May2024_A4

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# MASNA'A ADHBAN - Flood Hazard Model Map

## Yemen - Marib - Masna'a Adhban

*Flood Hazard 2024*

**0** Affected Buildings

**0** Affected Public Buildings

**Production Date : 30 May 2024**


A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Masnaa Adhban IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation..

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodHazard_MasnaaAdhban_30May2024_A4

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## Al-Sowayda

### Site background, historical flooding & vulnerability

Al-Sowayda has a population of 9185 site residents divided across 1735 HHs, making it the third largest IDP site in Marib and the fourth largest IDP site in Yemen. Based on SMT 2023 R8 data (November 2023), the site was self-settled, located in a rural area on private lands and lacks both a written and verbal tenancy agreement. Crucially, this complete absence of a tenancy agreement and location of the site on private lands may contribute to making flood preparedness, mitigation and anticipatory action interventions in the site more difficult.

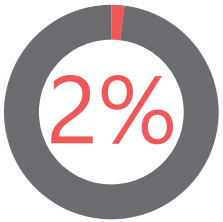
Al-Sowayda experienced flooding in March 2023, which, while resulting in no injuries or deaths to site residents, partially destroyed 883 site shelters and completely destroyed a further 27. The number of partially destroyed shelters during this flood was particularly concerning given that the site population is comprised of 1735 HHs as of March 2023. SMT data covering November 2023 indicated that approximately half of households' shelters required repair or maintenance, which could further heighten the sites' vulnerability in the event of future flooding.

**Evidence of preparedness measures**

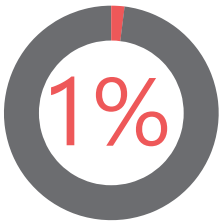
According to the 'Flood Hazard' maps below, several patches of 'very high' or 'extreme' hazard exist across the site, many of which overlap with areas of relatively high shelter density. For instance, a densely populated area with a mixture of 'Very High' and 'Extreme' severity zones exists next to the northernmost border of Block 5.

Image 4: Al-Sowayda IDP Site, provided by IOM, 2024

## Key Findings




of shelters in Al-Sowayda were categorised as 'High Hazard' according to the flood hazard modelling (n=93). Of these, 50 shelters were considered 'High Risk' according to **flood depth** models. This is **relatively low** in comparison to other assessed sites.




of shelters in Al-Sowayda site were classified with a 'High' **flood depth** severity, indicative of heightened vulnerabilities faced by HHs residing within this small minority of shelters.

All of the mapped grocery stores, schools, fuel stations and mosques were classified with a 'Low Hazard' classification.

# AL-SOWAYDA - Flood Depth Model Map

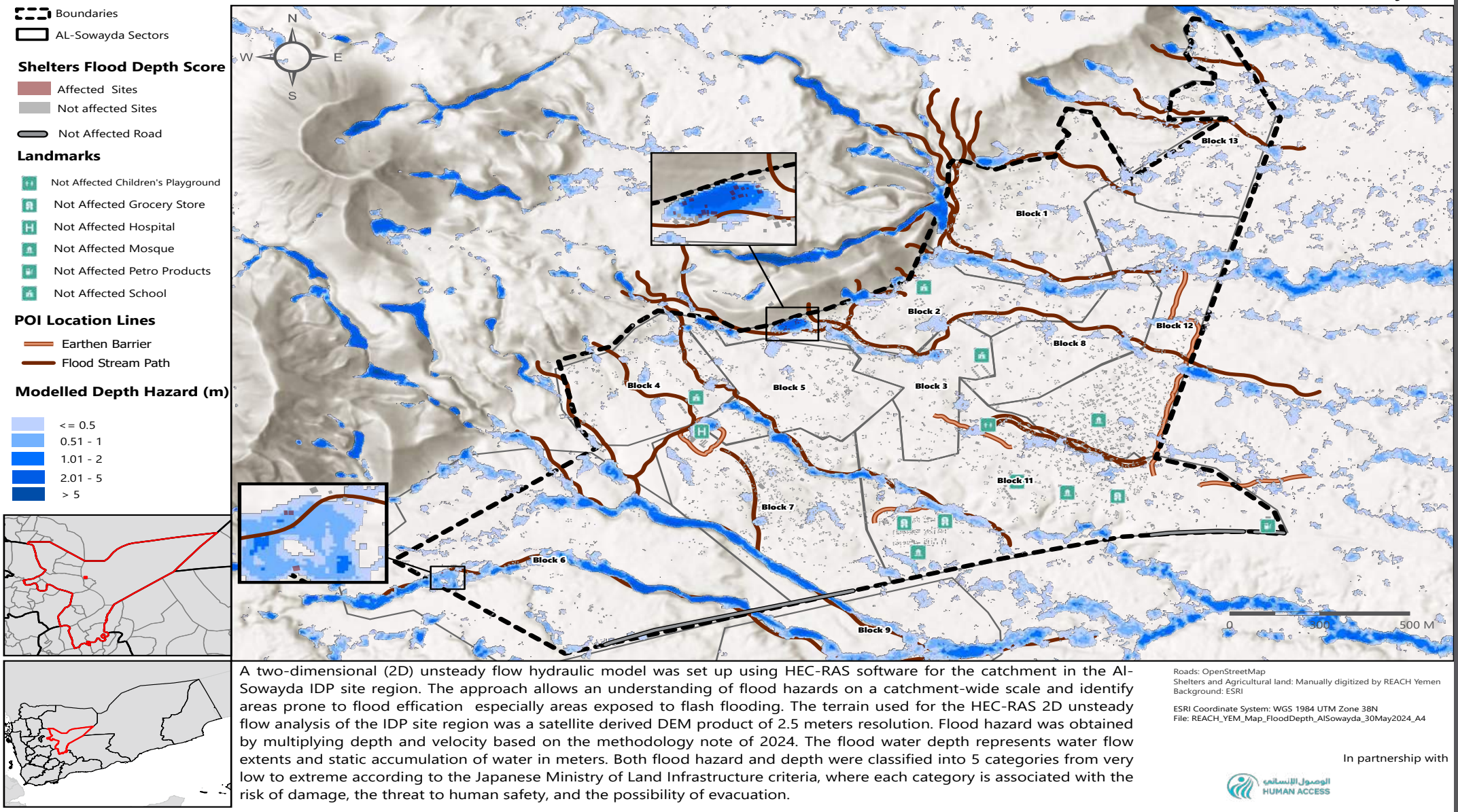
## Yemen - Marib - Al-Sowayda

*Flood Depth 2024*

**50** Affected Buildings

**0** Affected Public Buildings

**Production Date : 30 May 2024**




A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Sowayda IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation.

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodDepth_AlSowayda_30May2024_A4

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# AL-SOWAYDA - Flood Hazard Model Map

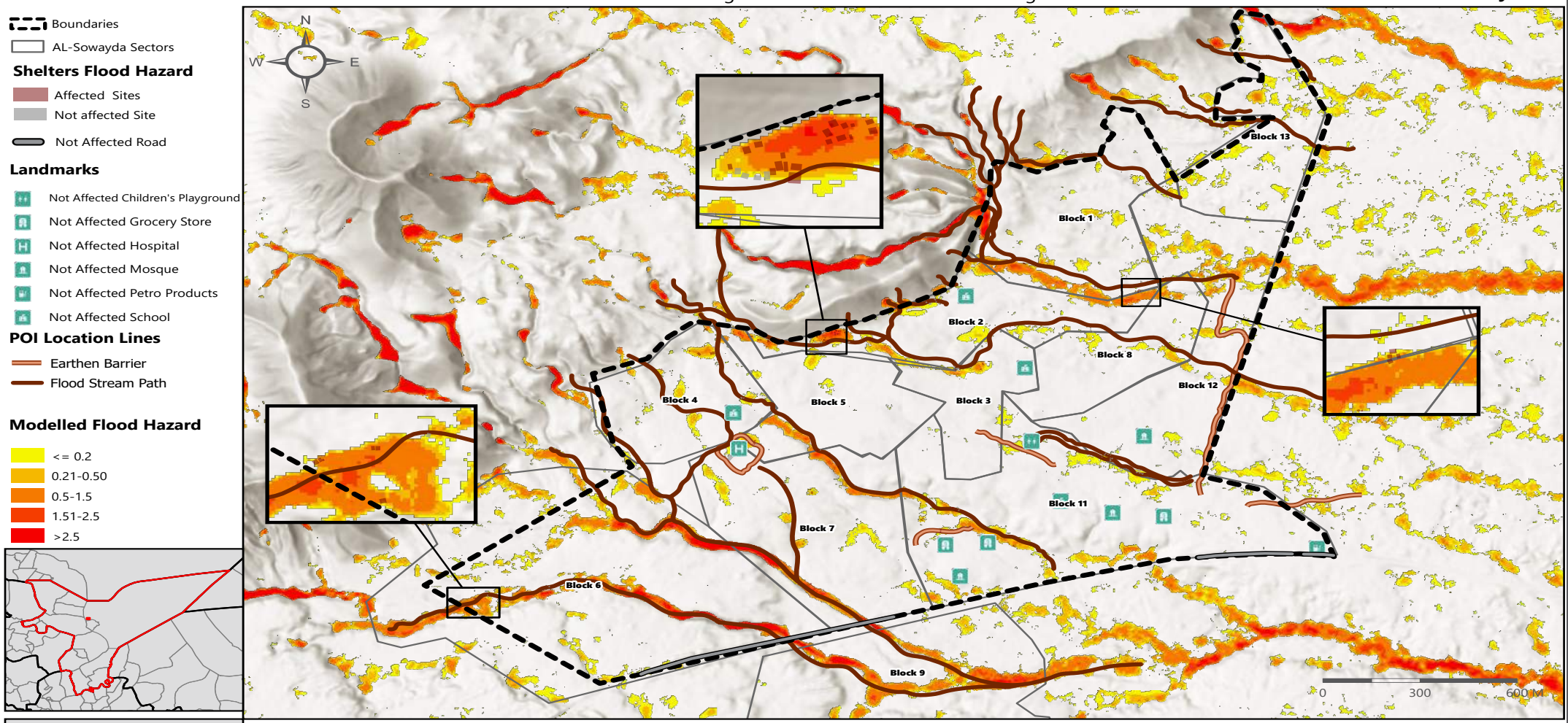
## Yemen - Marib - Al-Sowayda

*Flood Hazard 2024*

**96** Affected Building

**0** Affected Public Buildings

**Production Date : 30 May 2024**




A two-dimensional (2D) unsteady flow hydraulic model was set up using HEC-RAS software for the catchment in the Al-Sowayda IDP site region. The approach allows an understanding of flood hazards on a catchment-wide scale and identify areas prone to flood effication especially areas exposed to flash flooding. The terrain used for the HEC-RAS 2D unsteady flow analysis of the IDP site region was a satellite derived DEM product of 2.5 meters resolution. Flood hazard was obtained by multiplying depth and velocity based on the methodology note of 2024. The flood water depth represents water flow extents and static accumulation of water in meters. Both flood hazard and depth were classified into 5 categories from very low to extreme according to the Japanese Ministry of Land Infrastructure criteria, where each category is associated with the risk of damage, the threat to human safety, and the possibility of evacuation.

Roads: OpenStreetMap
Shelters and Agricultural land: Manually digitized by REACH Yemen
Background: ESRI

ESRI Coordinate System: WGS 1984 UTM Zone 38N
File: REACH_YEM_Map_FloodHazard_AlSowayda_30May2024_A4

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## Conclusion

This analysis aimed to build upon the 2024 REACH National Flood Hazard Analysis by providing an understanding of how flooding events could specifically impact selected sites in Marib governorate, in order to inform programmatic and operational planning. This analysis also saw REACH building on the foundations set by the 2022 pilot analysis in Abs district, whilst also incorporating a secondary data review of data available in the CCCM Cluster Flood Incident Report in addition to the REACH Site Monitoring Tool to improve understanding of how flooding events have historically affected IDPs residing in the assessed sites, and how site conditions may excacerbate their vulnerabilities.

Notably, this analysis found large differences between assessed sites in terms of the proportions of site shelters considered as having a 'high' flood hazard and/or flood depth exposure. Whilst nearly all shelters in Saylat-Alrumaylah were considered at high risk of exposure, the opposite was the case for Masna'a Adhban, despite both receiving a 'High' hazard classification in the 2024 REACH National IDP Site Flood Hazard Analysis.

This analysis is particularly important for the Yemen humanitarian response in-light of the conclusions of the REACH 2024 National Flood Hazard Analysis, which recommended the wider rollout of localised flood hazard assessments in order to determine appropriate, tailored and localised response plans to improve flood preparedness, mitigation and anticipatory action measures. Moreover, given that the 2024 REACH National Flood Hazard Analysis classified 20 sites with a 'Critical Hazard' susceptibility for flooding and a further 652 sites with a 'High Hazard', relevant CCCM Partners should conduct their own localised analysis in these areas in order to facilitate flood preparedness, anticipatory action and mitigation measures in sites. This is especially important in light of the reduction in funding across the Yemen humanitarian response.

Focal points at IOM have noted that:

*'Given the maps help provide us with an indication on the extent and severity of flood risks in certain areas, including impact on vulnerable populations and critical infrastructure, IOM can base its programmatic emergency plans, risk reduction measures and needed infrastructural improvements based on these maps.Flood risk reduction activities that can be considered include, but are not limited to: construction of Gabion walls, implementation of large-scale drainage channels, site leveling, and distribution of sandbags, while enhancing IDP HH shelters to be more flood resistant. In the longer run, IOM can also use these maps to build on durable interventions towards flood risk reduction which can limit environmental degradation by preventing flooding at the source, thus reducing the need for emergency shelter materials, such as plastic sandbags.'* IOM have BHA and ECHO supporting flood interventions in the sites they cover. In addition to the conclusions noted above by IOM, in-light of findings for sites like Saylat-Alrumaylah that face almost universal flood hazard exposure, site relocation is also a possibility to consider.

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## ABOUT REACH

REACH facilitates the development of information tools and products that enhance the capacity of aid actors to make evidence-based decisions in emergency, recovery and development contexts. The methodologies used by REACH include primary data collection and in-depth analysis, and all activities are conducted through inter-agency aid coordination mechanisms. REACH is a joint initiative of IMPACT Initiatives, ACTED and the United Nations Institute for Training and Research - Operational Satellite Applications Programme (UNITAR-UNOSAT). For more information please visit our website: www.reach-initiative.org. You can contact us directly at: geneva@reach-initiative.org and follow us on Twitter @REACH_info.