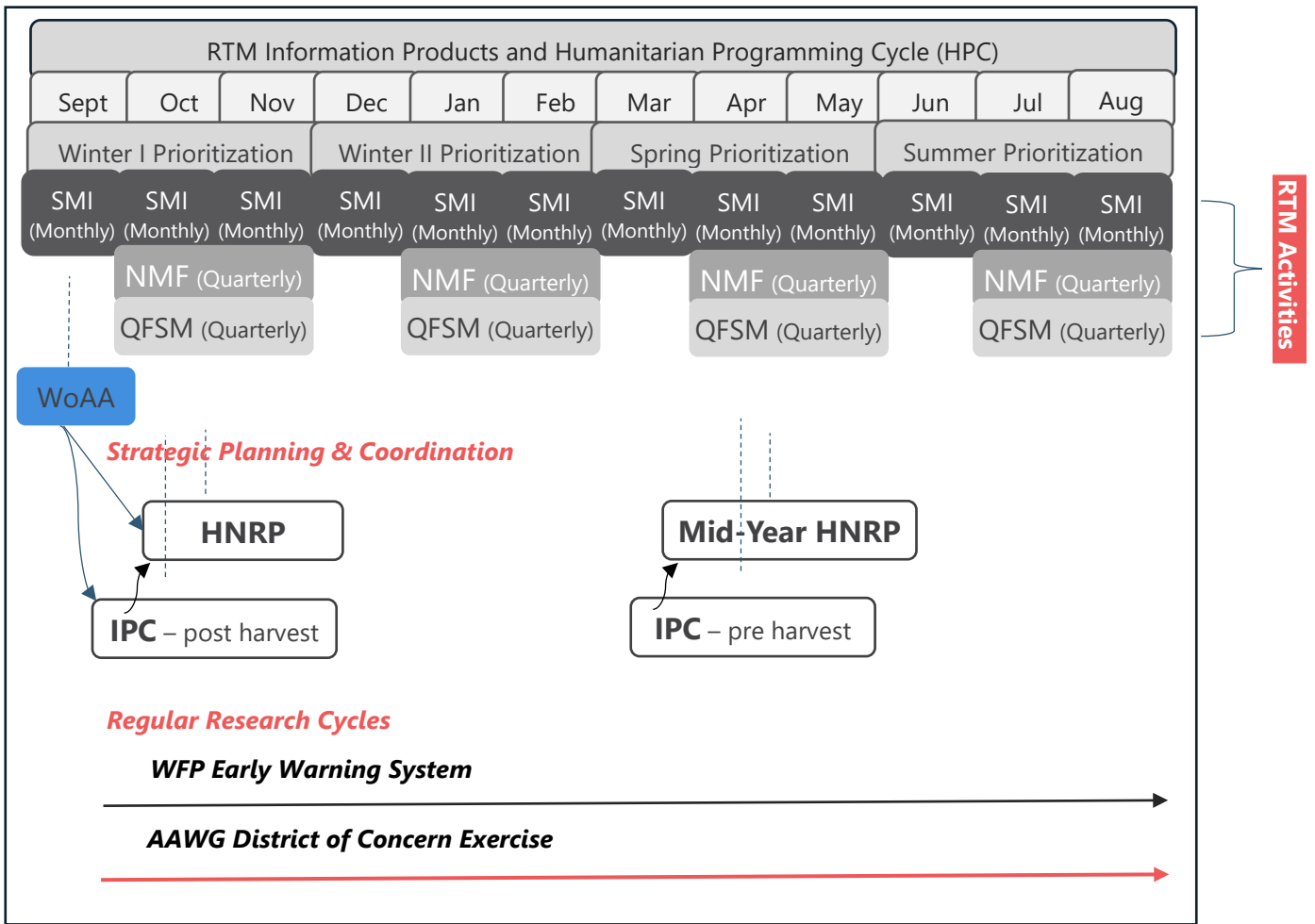


# REAL-TIME MONITORING SYSTEM REVIEW

January 2026, Afghanistan



## 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](#). You can contact us directly at: [geneva@reach-initiative.org](mailto:geneva@reach-initiative.org).

## Summary

In 2023, REACH, with the support of WFP and the Assessment and Analysis Working Group (AAWG), initiated the Real-Time Monitoring (RTM) system in Afghanistan. The primary objective of RTM is to contribute to collective humanitarian efforts by supporting the identification and anticipation of deteriorating needs, thereby enabling more timely and evidence-based prioritisation and pre-positioning of programmatic resources. RTM outputs provide regular updates on the status of multi-sectoral humanitarian needs and the key drivers of those needs, serving as an early warning mechanism for potential deterioration in the humanitarian situation.

Since the inception of RTM activities, three core analytical products—the Shock Monitoring Index (SMI),<sup>1</sup> the Needs Monitoring Framework (NMF),<sup>2</sup> and the Quarterly Food Security Monitoring (QFSM)<sup>3</sup>—have been produced and regularly disseminated to humanitarian actors. These products have been used to support decision-making, prioritisation, and coordination processes. In particular, SMI and QFSM have been extensively utilised by WFP within its early warning systems, strengthening hotspot analysis related to food security needs and identifying areas at risk of worsening conditions. In parallel, the AAWG regularly draws on SMI and NMF as key analytical inputs for its triggering mechanisms,<sup>4</sup> and for identifying districts experiencing high or increasing levels of humanitarian need.

Given the strategic importance of RTM outputs, REACH and AAWG continuously review and refine the RTM system and its analytical products to improve output quality, methodological robustness, and analytical accuracy. Building on earlier system refinements, the present study focuses on strengthening the analytical foundations of RTM by reviewing the underlying models for multicollinearity and model fit. The findings of this review have been incorporated into the data analysis plan, resulting in analytically improved and more robust model specifications across RTM products.

The system review was conducted using previously analysed data from the existing SMI, NMF, and QFSM systems. These products draw exclusively on secondary data sources, including REACH Humanitarian Situation Monitoring (HSM),<sup>5</sup> remote sensing indicators, ACLED, DHIS2, Nutrition Cluster GAM data, and other complementary datasets. The review focused on two core aspects of model specification. First, multicollinearity among indicators was assessed using Variance Inflation Factor (VIF) analysis. Second, model fit and construct validity were evaluated through Confirmatory Factor Analysis (CFA), to assess alignment between observed indicators and their underlying theoretical constructs.

Due to recent updates to the RTM systems in 2025, particularly within QFSM and NMF, several indicators changed across recent rounds. As a result, the system review was applied to a single round of data collected in December 2025, as extending the analysis to previous rounds with differing indicator sets was not methodologically feasible. This limitation reduced the effective sample size and may have had some impact on the precision of the findings; however, the results remain valid for assessing the current model specifications and informing ongoing RTM system refinement.

<sup>1</sup> Shock Monitoring Index (SMI) - [https://dashboards.impact-initiatives.org/afg/shocks\\_monitoring\\_index/](https://dashboards.impact-initiatives.org/afg/shocks_monitoring_index/)

<sup>2</sup> Needs Monitoring Framework (NMF) - <https://dashboards.impact-initiatives.org/afg/needs-monitoring/>

<sup>3</sup> Quarterly Food Security Monitoring (QFSM) - [https://repository.impact-initiatives.org/document/impact/48f43d06/REACH\\_AFG\\_Methodology-Note\\_QFSM\\_Dec2025.pdf](https://repository.impact-initiatives.org/document/impact/48f43d06/REACH_AFG_Methodology-Note_QFSM_Dec2025.pdf)

<sup>4</sup> Triggering mechanism: A joint activity among AAWG member to inform prioritization and systematic prompt action based on the available real time data.

<sup>5</sup> HSM: <https://reliefweb.int/report/afghanistan/afghanistan-humanitarian-situation-monitoring-hsm-round-10-district-tables-factsheet-march-2025>

## Key Findings

Quarterly Food Security Monitoring (QFSM), which contains four factor pillars (i.e., latent constructs) which are food accessibility, food availability, food utilization, and proxy-outcome level indicators. All of these factors rely on 19 indicators/variables. The multicollinearity check on the QFSM model identified no significant multicollinearity among the indicators.

In addition, the results of the CFA also demonstrated acceptable to excellent model fitting for QFSM. Therefore, the already existing model was identified as sufficient and acceptable for further analysis, and should be kept as is.

Needs Monitoring Framework (NMF) comprises 7 humanitarian sectors, which are set in the model as latent constructs of the underlying 29 indicators/variables. The multicollinearity check on the NMF through VIF measures indicate that little to no multicollinearity exists in the models. The CFA was applied independently on each sector construct, and all the sector models demonstrate acceptable to excellent fitting, except the Health sector construct. To reconstruct the Health sector model, the new latent constructs were identified through Exploratory Factor Analysis (EFA). The newly identified model demonstrates an acceptable level of model fit.

In addition to QFSM and NMF, the SMI drought monitoring model was reviewed as well. The SMI drought monitoring model consists of several indicators, ranging from meteorological drought to agricultural drought and heatwaves. The hypothesis to combine all these indicators under a single latent construct has been denied by CFA due to poor model fitting. In order to identify appropriate factors for the variables, the EFA was applied to the correlation matrix of observed variables underlying the model. Based on the EFA, the new proposed model contains 3 first-order latent factors: meteorological drought, snow condition, and SPI24. In addition to these latent factors, two second-order latent factors were suggested: agricultural drought and heatwaves. Finally, the overall drought severity will be defined based on 3 first-order constructs and 2 second-order latent constructs.

The system review exercise, through the application of the above statistical tests, has strengthened the analytical foundations of the RTM system and resulted in more robust, coherent, and precise monitoring models. These improvements enhance the reliability and interpretability of RTM outputs, thereby supporting more accurate prioritization, stronger anticipatory action, and more effective real-time monitoring of humanitarian needs and shocks across Afghanistan.

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## List of Acronyms

<b>AAWG:</b>	Assessment and Analysis Working Group
<b>ARI:</b>	Acute Respiratory Infection
<b>AWD:</b>	Acute Water Diarrhea
<b>CFA:</b>	Confirmatory Factor Analysis
<b>EFA:</b>	Exploratory Factor Analysis
<b>ESNFI:</b>	Emergency Shelter and Non-Food Item
<b>FS:</b>	Food Security
<b>HSM:</b>	Humanitarian Situation Monitoring
<b>NMF:</b>	Needs Monitoring Framework
<b>QFSM:</b>	Quarterly Food Security Monitoring
<b>RTM:</b>	Real-Time Monitoring
<b>SMI:</b>	Shock Monitoring Index
<b>SPI:</b>	Standard Precipitation Index
<b>SWE:</b>	Snow Water Equivalent
<b>VCI:</b>	Vegetation Condition Index
<b>VIF:</b>	Variation Inflation Factor
<b>WFP:</b>	World Food Programme

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## Introduction

Afghanistan has long been affected by compounded and protracted crises, with decades of conflict, sustained economic decline, and recurrent climate-related and natural hazards. REACH, with the support of the Assessment and Analysis Working Group (AAWG) and the World Food Programme (WFP), established the Real-Time Monitoring (RTM) system in 2023 to support timely, evidence-based humanitarian decision-making. The RTM system was designed to generate granular, systematic, and regularly updated data to track changes in key humanitarian outcomes across Afghanistan, such as food insecurity, exposure to shocks, and multi-sectoral vulnerability at the district level. By providing consistent sub-national monitoring, RTM strengthens the ability of humanitarian actors to detect emerging risks, identify priority areas, and adjust response strategies in line with rapidly evolving needs.

The RTM system currently comprises three core analytical products: the monthly Shock Monitoring Index (SMI), the quarterly Needs Monitoring Framework (NMF), and the Quarterly Food Security Monitoring (QFSM). These outputs integrate and synthesise a broad range of secondary data sources, including REACH's Humanitarian Situation Monitoring (HSM), remote sensing indicators, ACLED conflict data, DHIS2 health data, and Nutrition Cluster information. Together, these sources enable district-level monitoring of both the drivers of vulnerability and their observable manifestations. RTM outputs feed directly into early warning mechanisms, inter-sectoral analysis, and planning processes, supporting coordination actors in anticipating deteriorations in needs rather than responding only once impacts are fully realised.

Given the growing reliance on RTM outputs for strategic planning and early warning, REACH, with the support of WFP and AAWG, undertook a system review to strengthen the analytical validity and internal coherence of RTM models. The review focused on assessing the statistical relationships between indicators, testing for multicollinearity, and evaluating the extent to which selected indicators appropriately capture the intended latent constructs underpinning needs and shock severity analysis. Confirmatory Factor Analysis (CFA) was applied to assess model fit, with Variance Inflation Factors (VIF) used to examine correlations among indicators. The analysis drew on the most recent rounds of QFSM and NMF data collected in December 2025, using complete indicator sets to ensure comparability and avoid bias arising from indicator changes across rounds.

Across models, multicollinearity assessments indicated acceptable levels of correlation among indicators. Where CFA results suggested sub-optimal model fit, Exploratory Factor Analysis (EFA) was applied to further examine indicator groupings and refine the underlying factor structure. This iterative analytical approach allowed for the identification of more conceptually coherent and statistically robust latent constructs, ensuring that indicators load meaningfully onto the factors they are intended to represent.

The revised RTM system models demonstrate improved alignment between observed indicators and underlying latent factors, strengthening the robustness and interpretability of analytical outputs. This is particularly critical for sectoral and multisectoral needs severity analysis, where mis-specified constructs can obscure key drivers of vulnerability or distort severity signals. By restructuring indicators under more appropriate latent dimensions, the revised models enhance analytical precision and improve the system's capacity to monitor needs and vulnerabilities associated with specific shock and risk profiles. Collectively, these refinements reinforce RTM's role as a reliable, decision-relevant monitoring system that supports anticipatory action and informed prioritisation across the humanitarian response.

## Methodology.

### Sampling strategy

**Quarterly Food Security Monitoring (QFSM)** QFSM analysis is derived from HSM Round 11 data collected in November–December 2025 (sample size = 12,214 KIs). For the system review, QFSM indicators which were aggregated to the district level, and each district constitutes one analytical observation. Accordingly, the sample used for the system review comprised 401 district-level observations, corresponding to the full set of districts analysed in QFSM Round 7 (December 2025). This district-level dataset was used for both the multicollinearity assessment and the Confirmatory Factor Analysis (CFA).

**Needs Monitoring Framework (NMF):** NMF Round 8 analysis is based on HSM data collected in November–December 2025 (sample size = 12,214 KIs), complemented by secondary data sources. Analysis is conducted at the district level, with indicators aggregated to produce one observation per district. In Round 8, this comprised a total of 401 district-level observations. The same 401-district dataset was used for the system review, including the assessment of multicollinearity and model fit through Confirmatory Factor Analysis (CFA).

**Shock Monitoring Index (SMI) – Drought Model:** For the SMI drought model, the sample selection followed a different approach due to the use of time-series data. Observations were selected from months in which all required indicators were available and no indicators were excluded due to seasonality constraints. As a result, data from April 2023 to November 2025 were included, yielding approximately 2,000 observations for the system review of the SMI drought model.

In both QFSM and NMF, recent framework revisions, following findings from the Area of Knowledge (AoK) validation study and internal methodological discussions led to the exclusion or modification of several indicators previously used in earlier rounds. Consequently, indicator sets in recent rounds are not fully comparable with those used in earlier iterations of the models. To avoid introducing bias arising from inconsistent indicator specifications, the system review for QFSM and NMF was therefore restricted to the most recent round only, using the 401 districts available in December 2025.

### Data collection methods

All data used in this assessment are drawn from existing analyses within the RTM systems, namely the Needs Monitoring Framework (NMF), Quarterly Food Security Monitoring (QFSM), and Shock Monitoring Index (SMI). These RTM products rely exclusively on secondary data sources, including REACH Humanitarian Situation Monitoring (HSM), remote sensing datasets, ACLED, DHIS2, and other complementary data sources used within the RTM system.

## Analysis

### Multicollinearity Assessment (VIF)<sup>6</sup>

To support model parsimony and reduce potential estimation bias, a multicollinearity assessment was conducted for each model. Multicollinearity was evaluated using linear regression models, with the Variance Inflation Factor (VIF) calculated for each indicator. VIF thresholds were interpreted as follows:

- VIF = 1 → No correlation among predictors
- VIF between 1 and 5 → Moderate correlation
- VIF > 5 → Potential multicollinearity concern (commonly used warning threshold)
- VIF > 10 → Serious multicollinearity issue

Indicators exceeding acceptable VIF thresholds were reviewed for exclusion or consolidation to improve model stability.

### Factor Structure Assessment (CFA and EFA)

To assess whether the QFSM, NMF, and SMI models align with their underlying theoretical constructs, and to verify whether indicators load appropriately onto their intended latent variables, both Confirmatory Factor Analysis (CFA) and Exploratory Factor Analysis (EFA) were applied.

### Confirmatory Factor Analysis (CFA)<sup>7</sup>

An initial CFA was conducted for each model using maximum likelihood estimation to test the hypothesized factor structure. Model fit was assessed using the following goodness-of-fit indices:

- Chi-Square goodness-of-fit statistic
- Comparative Fit Index (CFI)
- Tucker–Lewis Index (TLI)
- Root Mean Square Error of Approximation (RMSEA)

Models meeting established fit criteria across these indices were considered to demonstrate adequate construct validity. Where models failed to meet minimum fit thresholds, further exploratory analysis was undertaken.

### Exploratory Factor Analysis (EFA)<sup>8</sup>

For models that did not achieve acceptable fit in CFA, a maximum likelihood EFA was applied to reassess the underlying factor structure. The number of latent factors was determined based on scree plot inspection and eigenvalues greater than 1, in line with standard practice. Indicators with factor loadings below 0.30 were excluded from the model.

The revised factor structure identified through EFA was subsequently subjected to a second round of CFA to confirm model fit and validate the refined construct specification.

<sup>6</sup> Variation Inflation Factor (VIF): VIF is a great tool for detecting multicollinearity, offering insights beyond simple pairwise correlations. Find more details here - <https://www.datacamp.com/tutorial/variance-inflation-factor>

<sup>7</sup> Confirmatory Factor Analysis (CFA): CFA is a statistical method used to test whether a set of observed variables accurately reflects a smaller number of underlying latent factors based on a predefined theoretical model – find more details here : <https://www.geeksforgeeks.org/data-science/confirmatory-factor-analysis/>

<sup>8</sup> Factor Analysis: Factor Analysis is a statistical technique used in data analysis to identify hidden patterns or underlying relationships among a large set of variables- find more details here: <https://www.geeksforgeeks.org/machine-learning/introduction-to-factor-analytics/>

## Challenges and Limitations

Variations in indicator availability across rounds limited the ability to apply the system review across a larger sample size. To avoid bias and potential mis-specification arising from inconsistent indicator sets, the system review was therefore restricted to the most recent round in which all relevant indicators were available and equally represented in the analysis.

In addition, some indicators are subject to seasonality and environmental or geographic constraints, resulting in their exclusion during specific periods. To ensure that model assessments were conducted using a complete and comparable indicator set, only rounds in which all required indicators were present were selected for inclusion in the system review.

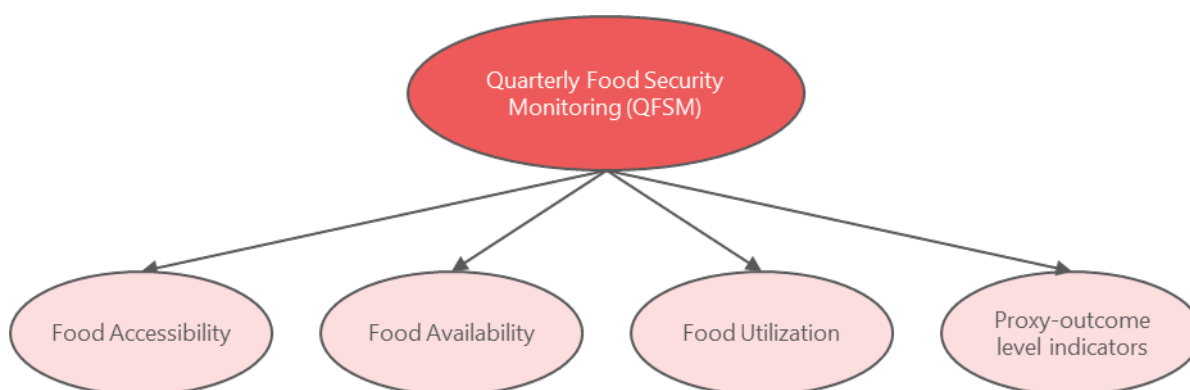
## Findings

### Quarterly Food Security Monitoring (QFSM):

The Quarterly Food Security Monitoring (QFSM) framework comprises approximately 20 indicators, with minor variation across rounds to reflect contextual relevance and data availability. All indicators are derived from Humanitarian Situation Monitoring (HSM), a nationwide, quarterly key informant (KI)-level survey implemented by REACH in Afghanistan. Food security-related indicators are selected from the HSM dataset and structured around the three core food security pillars—food availability, food access, and food utilization—supplemented by two indicators proxying second-level food security outcomes.

Since the launch of QFSM in Fall 2023, REACH has continuously reviewed and refined the framework to ensure indicator relevance, internal coherence, and analytical robustness. This process was informed in particular by an Area of Knowledge (AoK) validation study conducted by REACH during 2024–2025, which examined the appropriateness of KI-level data for analytical use across products, including QFSM. Based on the AoK findings, indicators identified as insufficiently reliable or unsuitable for KI-level measurement were revised or removed. Following these adjustments, the remaining indicators were subjected to multicollinearity assessment, Confirmatory Factor Analysis (CFA), and Exploratory Factor Analysis (EFA) applied separately for each food security pillar to ensure a reliable and well-structured analytical model. The results of these analyses are presented below.

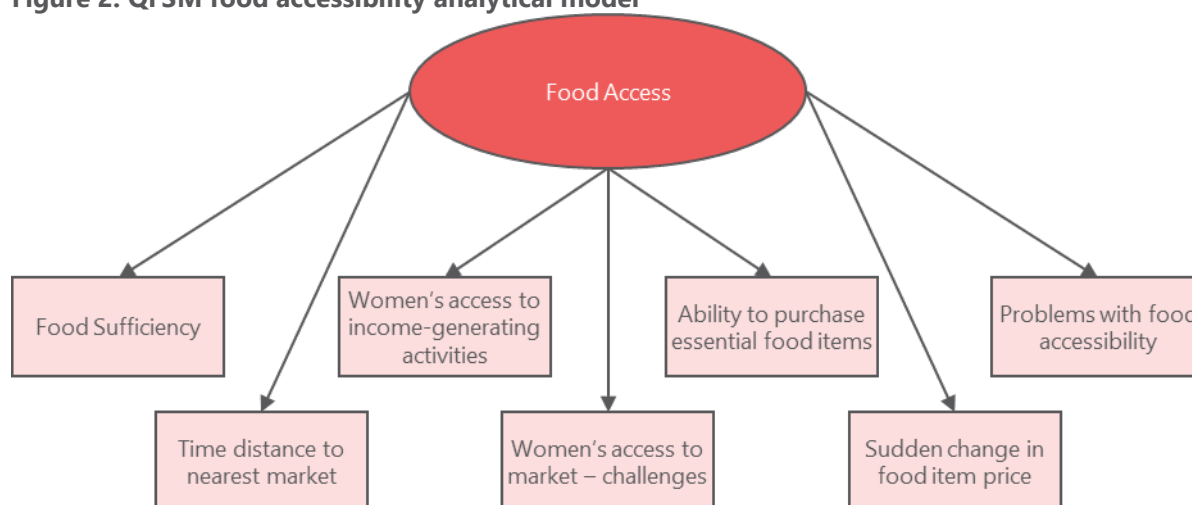
**Figure 1: QFSM Framework**



## Food Accessibility Pillar

The Food Access pillar within QFSM comprises seven indicators. In the current analytical specification, all indicators are aggregated under a single latent construct representing food access.

**Figure 2: QFSM food accessibility analytical model**



### Multicollinearity Check

A multicollinearity assessment was conducted across the seven indicators using the Variance Inflation Factor (VIF). The results indicate no evidence of problematic multicollinearity, confirming that the indicators can be jointly retained in the model without inflating parameter estimates or introducing instability.

The food access construct is specified as follows:

$$\text{Food Access}_i = \beta_0 + \beta_1 \text{Access1}_i + \beta_2 \text{Access2}_i + \dots + \beta_7 \text{Access7}_i + \varepsilon_i$$

**Table 1: Food access multicollinearity assessment table**

Variable	VIF	Multicollinearity Rating
Food sufficiency	1.82	No multicollinearity
Time distance to nearest market	1.02	No multicollinearity
Women access to income generating activities	1.14	No multicollinearity
Ability to purchase essential food items	1.79	No multicollinearity
Problems with food accessibility	1.2	No multicollinearity
Sudden change in food item price	1.08	No multicollinearity
Women access to market - challenges <sup>9</sup>	NA	NA

<sup>9</sup> This indicator due to access challenges have been excluded from HSM R11 data collection, as a result the data didn't exist for VIF assessment.

### Model Fit – Confirmatory Factor Analysis (CFA)

Following the multicollinearity assessment, a Confirmatory Factor Analysis (CFA) was conducted to estimate the latent food access construct using six observed indicators from the food access pillar. The model specified a single latent factor, with all six indicators allowed to load freely onto the food access construct. This specification was informed by theoretical considerations related to the access dimension of food security and reflects the assumption that the selected indicators capture a common underlying access-related construct.

The CFA model is specified as follows:

$$\text{Food Access}_i = \lambda_1 \text{Access1}_i + \lambda_2 \text{Access2}_i + \lambda_3 \text{Access3}_i + \lambda_4 \text{Access4}_i + \lambda_5 \text{Access5}_i + \lambda_6 \text{Access6}_i + \varepsilon_i$$

**Table 2: CFA model fit indices for the QFSM food accessibility model**

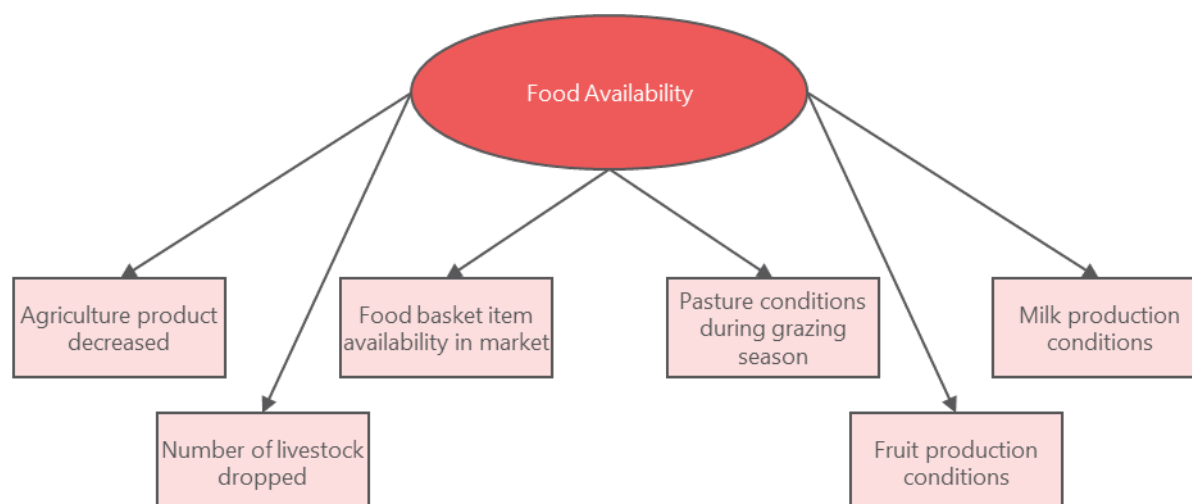
Index	Value	Interpretation
$\chi^2$ (df = 9)	27.01	Statistically significant
p-value	0.001	Indicates misfit (expected with moderate/large samples)
CFI	0.947	Acceptable–good ( $\geq 0.95$ ideal; $\geq 0.90$ acceptable)
TLI	0.911	Acceptable, but slightly below ideal
RMSEA	0.071	Acceptable / borderline ( $\leq 0.06$ ideal; $\leq 0.08$ acceptable)
SRMR	0.049	Good ( $\leq 0.08$ acceptable; $\leq 0.05$ very good)

**Conclusion:** Overall, the confirmatory factor analysis demonstrated an acceptable model fit. Incremental fit indices (CFI = 0.95; TLI = 0.91) indicate good model performance relative to a null model, while residual-based measures (SRMR = 0.05; RMSEA = 0.07) fall within commonly accepted thresholds. Although the chi-square test was statistically significant ( $\chi^2(9) = 27.01$ ,  $p = 0.001$ ), this result is expected given the sensitivity of the test to sample size and does not, on its own, indicate poor fit. Taken together, the results suggest that the specified model provides an adequate representation of the underlying data structure.

### Food Availability Pillar

The food availability pillar within QFSM comprises six indicators capturing community-level conditions related to the availability of food, as reported by key informants (KIs).

**Figure 3: QFSM food availability analytical model**



### Multicollinearity Check

A multicollinearity assessment was conducted for the Food Availability model using the Variance Inflation Factor (VIF). The results indicate no evidence of problematic multicollinearity among the six food availability indicators, confirming that all variables can be retained in the model without risk of inflated variance or unstable coefficient estimates.

The regression specification used for the VIF assessment is as follows:

$$\text{Food Availability}_i = \beta_0 + \beta_1 \text{Availability1}_i + \beta_2 \text{Availability2}_i + \dots + \beta_6 \text{Availability6}_i + \varepsilon_i$$

**Table 3: Food availability multicollinearity assessment table**

Variable	VIF	Multicollinearity Rating
Agriculture product decreased	1.28	No multicollinearity
Number of Livestock dropped	1.17	No multicollinearity
Food basket items availability in market	1.06	No multicollinearity
Pasture condition during grazing season	2.09	Low multicollinearity
Fruit production condition	1.36	No multicollinearity
Milk production condition	1.87	No multicollinearity

All indicators in the current model fall within acceptable VIF thresholds, indicating no meaningful multicollinearity.

### Confirmatory Factor Analysis (CFA)

After confirming the absence of problematic multicollinearity among the indicators, a Confirmatory Factor Analysis (CFA) was conducted to assess the fit of the food availability measurement model. The model specifies a single latent food availability construct, with all six observed indicators loading freely onto the latent factor.

The CFA model is specified as follows:

$$\begin{aligned} \text{Food Availability}_i &= \lambda_1 \text{Availability1}_i + \lambda_2 \text{Availability2}_i + \lambda_3 \text{Availability3}_i + \lambda_4 \text{Availability4}_i \\ &+ \lambda_5 \text{Availability5}_i + \lambda_6 \text{Availability6}_i + \varepsilon_i \end{aligned}$$

**Table 4: CFA model fit indices for the QFSM food availability model**

Index	Value	Interpretation
$\chi^2$ (df = 9)	19.16 (p = 0.024)	Statistically significant (extremely sensitive to sample size)
CFI	0.95	Acceptable fit
TLI	0.917	Acceptable fit
RMSEA	0.078	Acceptable (not excellent) fit
SRMR	0.053	Good fit

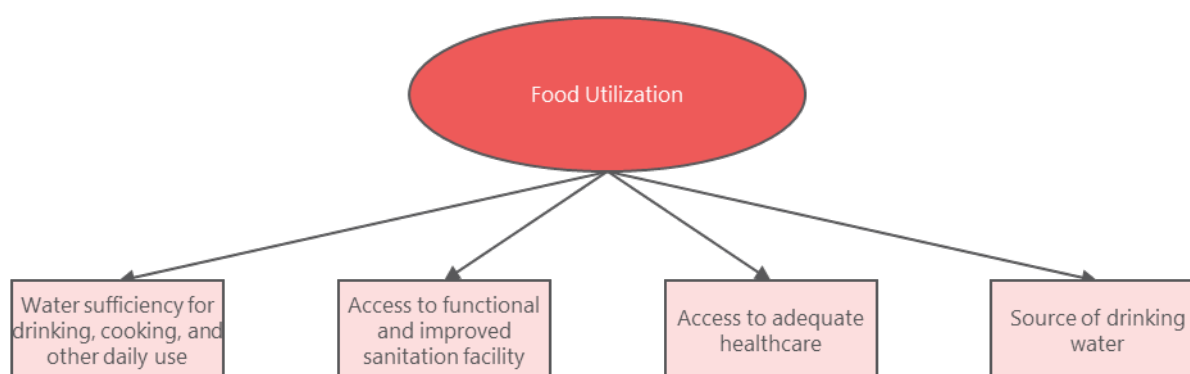
**Conclusion:** The confirmatory factor analysis indicates an overall acceptable model fit. While the chi-square test was statistically significant ( $\chi^2(9) = 19.16$ ,  $p = 0.024$ ), this result is expected given the sensitivity of the test to sample size and is not considered decisive on its own. Complementary fit indices provide a more informative assessment: the CFI (0.95) and TLI (0.92) indicate acceptable incremental fit, while residual-based measures (RMSEA = 0.078; SRMR = 0.053) fall within commonly accepted

thresholds. Taken together, these results suggest that the specified model provides an adequate representation of the underlying data structure and is suitable for subsequent analysis.

## Food Utilization Pillar

Food utilization constitutes the third core pillar of the QFSM framework, in line with standard food security conceptual models. The food utilization pillar comprises four indicators, all of which are derived from Humanitarian Situation Monitoring (HSM) KI-level data.

**Figure 4: QFSM food utilization analytical model**



## Multicollinearity Check

A multicollinearity assessment for the food utilization pillar indicators was conducted using the Variance Inflation Factor (VIF), as described below.

$$\text{Food Utilization}_i = \beta_0 + \beta_1 \text{Utilization1}_i + \beta_2 \text{Utilization2}_i + \beta_3 \text{Utilization3}_i + \beta_4 \text{Utilization4}_i + \varepsilon_i$$

**Table 5: QFSM food utilization multicollinearity assessment**

Variable	VIF	Multicollinearity Rating
Water sufficiency for drinking, cooking, and other daily use	1.06	No multicollinearity
Access to functional and improved sanitation facility	1.08	No multicollinearity
Access to adequate healthcare	1.05	No multicollinearity
Source of drinking water	1.03	No multicollinearity

Based on the Variance Inflation Factor (VIF) results, there is no evidence of multicollinearity among the food utilization indicators.

## Confirmatory Factor Analysis – Food Utilization

After confirming the absence of multicollinearity among the indicators, a Confirmatory Factor Analysis (CFA) was conducted on the food utilization model to assess model fit

$$\text{Food utilization}_i = \lambda_1 \text{utilization1}_i + \lambda_2 \text{utilization2}_i + \lambda_3 \text{utilization3}_i + \lambda_4 \text{utilization4}_i + \varepsilon_i$$

**Table 6: CFA model fit indices for the QFSM food utilization model**

Index	Value	Interpretation
$\chi^2$ (df = 2)	0.374	Very small
p-value	0.83	Non-significant → no evidence of misfit
CFI	1	Excellent
TLI	1.124	>1 due to very good fit (acceptable, report as is)
RMSEA	0	Excellent
SRMR	0.008	Excellent

**Conclusion:** The confirmatory factor analysis demonstrates an excellent model fit across all evaluated indices. The chi-square test was non-significant ( $\chi^2(2) = 0.37$ ,  $p = 0.83$ ), indicating no evidence of model misfit. Incremental fit indices show perfect or near-perfect fit (CFI = 1.00; TLI = 1.12), while residual-based measures (RMSEA = 0.00; SRMR = 0.01) further confirm an exceptionally close correspondence between the model-implied and observed covariance structures. Collectively, these results indicate that the specified model provides a very strong representation of the underlying data structure and is well suited for subsequent analysis.

### Perceived Level of Hunger and Livelihood

In addition to the three core food security pillars, the QFSM framework includes a Perceived Level of Hunger and Livelihood component. This section comprises two indicators that proxy key second-level food security outcomes related to household hunger and livelihood coping strategies.

Ind 1: % of settlements where KIs reporting on the perceived level of hunger among the households

Ind 2: % settlements where KIs reporting doing unusual things to obtain food in the past 30 days

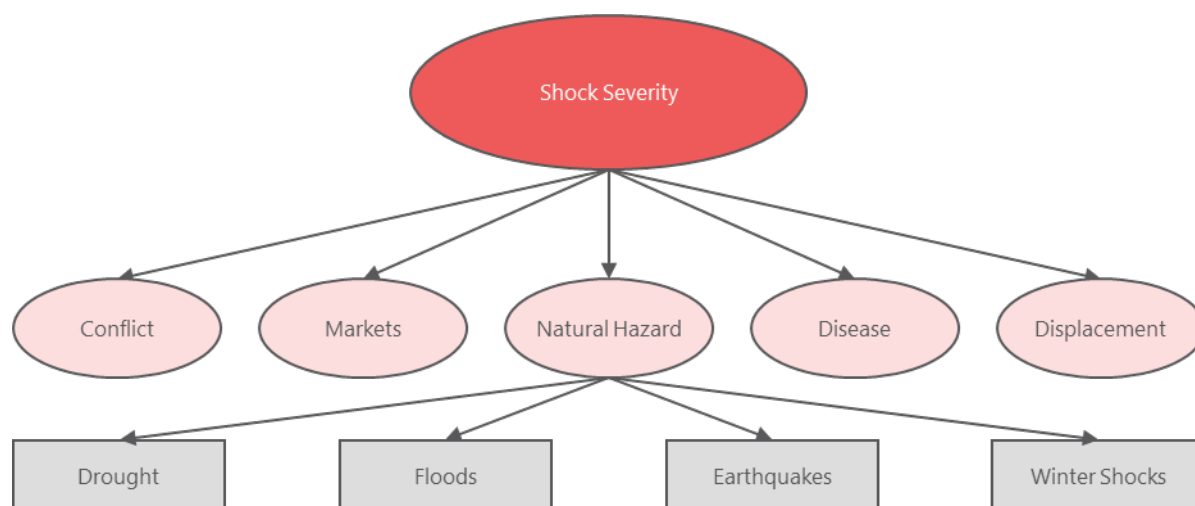
Given the limited degrees of freedom associated with a two-indicator specification, formal multicollinearity testing and CFA) were not conducted for this component, as such procedures are not statistically appropriate or informative in this context. Instead, indicator selection was guided by conceptual relevance and informed by the findings of the Area of Knowledge (AoK) validation study, which assessed the suitability of KI-level indicators for analytical use.

At the bivariate level, the correlation between the two indicators in QFSM Round 7 was 0.31, indicating a moderate positive association while suggesting that each indicator captures a distinct aspect of food security outcomes.

### Shock Monitoring Index (SMI) – Drought Monitoring

The Shock Monitoring Index (SMI) is a core analytical product of the Real-Time Monitoring (RTM) system. It is designed to systematically track and analyse the incidence, severity, and interaction of key shocks—including conflict, natural hazards, disease, markets, and displacement—at the district level across Afghanistan. By integrating advanced data analysis techniques with remote sensing indicators and other secondary data sources, the SMI produces monthly updates that support a nuanced and timely understanding of the evolving shock and risk landscape. These updates enable humanitarian actors to identify emerging areas of concern, monitor trends over time, and inform anticipatory action and response prioritisation.

Figure 5: SMI analytical model



## System Review

Within the Shock Monitoring Index (SMI), each pillar is typically composed of one to three underlying indicators. An exception is the Natural Hazards pillar, which is structured into four sub-pillars, each drawing on its own distinct set of indicators. This hierarchical structure reflects the diverse nature of hazard-related shocks and the different data sources required to monitor them.

With the exception of the drought sub-pillar, all other SMI pillars and sub-pillars rely on a limited number of indicators (i.e., one to three), resulting in very low degrees of freedom for statistical testing. In addition, several pillars are constructed using outcome-based indicators—such as reported violence incidents, disease outbreaks, or flooding events—where observed values directly represent shock occurrence rather than latent constructs inferred from multiple indicators. Given these characteristics, these pillars were not considered suitable for model testing through factor analysis and were therefore excluded from the system review.

As a result, the system review focused exclusively on the drought construct within the SMI, which is uniquely suited to latent variable modelling due to its reliance on a broader set of environmental and climate-related indicators. The SMI drought model was originally designed to capture different dimensions of drought conditions, including precipitation anomalies, vegetation stress, snow dynamics, and heatwave exposure. Together, these indicators are intended to identify whether districts are experiencing deteriorating conditions, improving conditions, or relative stability over time.

To assess the theoretical coherence and statistical robustness of the SMI drought model, the system review examined both multicollinearity among indicators and overall model fit. This involved testing whether the selected indicators appropriately represent the underlying drought construct and whether their relationships allow for reliable aggregation into a single severity measure.

The initial drought severity model was specified as follows:

$$\begin{aligned}
 \text{Drought Severity}_i &= \beta_1 \text{ Accumulated Precipitation}_{6,i} + \beta_2 \text{ Accumulated Precipitation}_{12,i} + \beta_3 \text{ SPI}_{3,i} \\
 &+ \beta_4 \text{ Early Snow Depletion}_i + \beta_5 \text{ Snow Water Equivalent}_i + \beta_6 \text{ SPI}_{24,i} + \beta_7 \text{ VCI}_i \\
 &+ \beta_8 \text{ Heatwave}_i + \varepsilon_i
 \end{aligned}$$

## Multicollinearity Check

To assess whether multicollinearity was present in the SMI drought model, Variance Inflation Factor (VIF) diagnostics were applied to each indicator.

**Table 7: SMI drought model multicollinearity assessment table**

Variable	VIF	Interpretation
Accumulated Precipitation 6 month	4.26	Moderate collinearity
Accumulated Precipitation 12 month	4.07	Moderate collinearity
SPI-3	2.34	Low collinearity
Early Snow Depletion	1.64	Very low collinearity
Snow water equivalent	1.55	Very low collinearity
SPI-24	1.48	Very low collinearity
Vegetation Condition Index (VCI)	1.25	Very low collinearity
Heat wave	1.87	Very low collinearity

Based on the Variance Inflation Factor (VIF) results, no serious multicollinearity is observed among the drought indicators. While a small number of indicators exhibit moderate levels of multicollinearity, these remain within acceptable thresholds and do not compromise model stability or interpretability.

## Confirmatory Factor Analysis (CFA)

To assess whether the existing SMI drought model adequately reflects its underlying theoretical construct, Confirmatory Factor Analysis (CFA) was applied. CFA was used to test the extent to which the selected indicators collectively capture a single latent drought severity construct, based on the model's original conceptual design.

For the purposes of CFA estimation, the drought severity construct was specified as a linear latent variable model, irrespective of its graphical representation in the conceptual framework. The model specification was as follows:

$$\begin{aligned} \text{Drought Severity}_i &= \beta_1 \text{Accumulated Precipitation}_{6,i} + \beta_2 \text{Accumulated Precipitation}_{12,i} + \beta_3 \text{SPI}_{3,i} \\ &+ \beta_4 \text{Early Snow Depletion}_i + \beta_5 \text{Snow Water Equivalent}_i + \beta_6 \text{SPI}_{24,i} + \beta_7 \text{VCI}_i \\ &+ \beta_8 \text{Heatwave}_i + \varepsilon_i \end{aligned}$$

**Table 8: CFA model fit indices for the SMI Drought model**

Fit Index	Value	Interpretation
$\chi^2$ (df = 20)	885.58	Large and significant
p-value	<0.001	Poor absolute fit
CFI	0.739	Below acceptable threshold
TLI	0.635	Poor incremental fit
RMSEA	0.279	Very poor fit
SRMR	0.138	Poor fit

The CFA results indicate poor overall model fit. The chi-square statistic is large and statistically significant, suggesting a substantial discrepancy between the observed and model-implied covariance matrices. Incremental fit indices (CFI and TLI) fall well below commonly accepted thresholds ( $\geq 0.90$ ), while absolute fit indices (RMSEA and SRMR) substantially exceed recommended cut-offs ( $\leq 0.08$ ). Collectively, these results indicate that the specified single-factor drought model does not adequately represent the underlying data structure.

Given the poor CFA results, Exploratory Factor Analysis (EFA) was subsequently applied to re-examine the underlying factor structure and inform model restructuring. The EFA results indicate that the drought indicators cluster into three distinct latent factors, suggesting that drought severity in the SMI is better represented as a multidimensional construct rather than a single latent factor. In addition, several indicators demonstrated weak loadings or cross-loadings and did not load meaningfully onto any factor. While these indicators were excluded from the revised latent model specification, they remain analytically relevant and may be retained as standalone or external indicators due to their operational importance.

**Table 9: SMI drought indicators factor loading**

Variable	ML2	ML3	ML1
Accumulated Precipitation 6 month	<b>0.95</b>	<b>-0.06</b>	<b>0.03</b>
SPI-3	<b>0.79</b>	0.09	-0.19
Accumulated Precipitation 12 month	<b>0.83</b>	0.03	0.14
SPI-24	<b>0.02</b>	0.01	<b>0.99</b>
Early Snow Depletion	0	<b>0.89</b>	0.05
Snow water equivalent	0.01	<b>0.65</b>	-0.1
Vegetation Condition Index (VCI)	0.24	0.13	0.24

In the factor analysis, the heatwave indicator was excluded from the EFA due to its temporal misalignment with the other drought indicators. Heatwave metrics capture short-duration, seasonal extremes concentrated in warmer months, whereas the remaining indicators reflect cumulative or longer-term hydro-meteorological conditions. Including the heatwave indicator would therefore have biased the factor structure toward summer periods and obscured underlying drought dynamics across the full annual cycle.

Based on the EFA results, the remaining indicators grouped into three distinct latent factors:

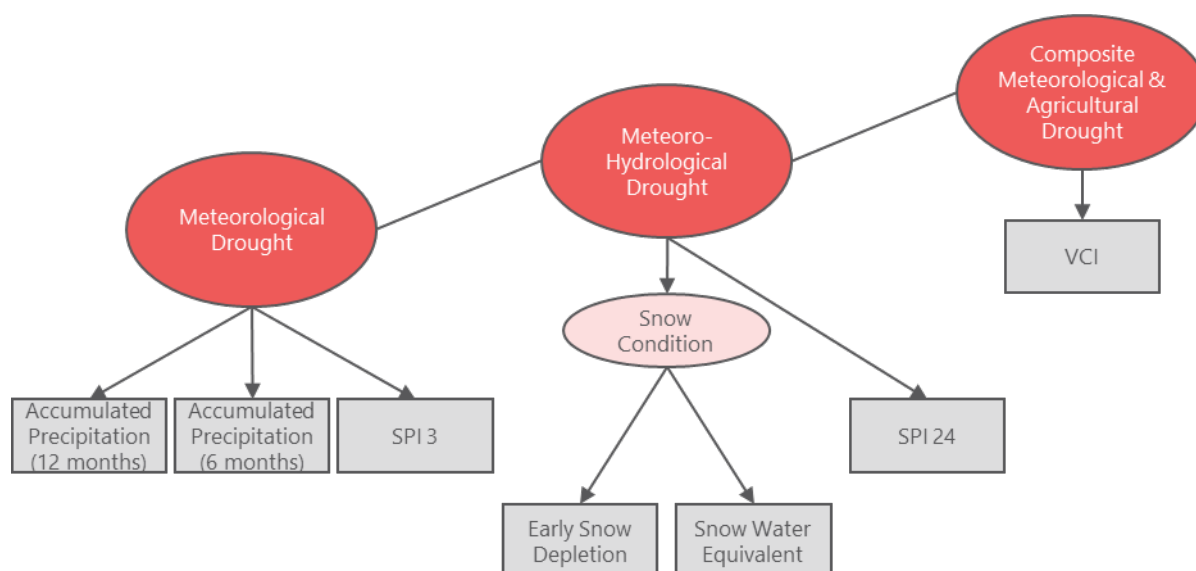
- **ML2: Short- to medium-term meteorological drought**, represented by accumulated precipitation anomalies and the 3-month Standardized Precipitation Index (SPI-3);
- **ML3: Snow-related hydrological stress**, captured through early snow depletion and Snow Water Equivalent (SWE); and
- **ML1: Long-term drought signal**, represented by the 24-month Standardized Precipitation Index (SPI-24).

Although the Vegetation Condition Index (VCI) is conceptually critical for understanding drought impacts on vegetation and agricultural stress, EFA results indicated that VCI did not load strongly onto any of the identified latent factors. As a result, VCI was excluded from the latent drought severity model as an endogenous indicator. However, given its analytical and operational importance, VCI is retained as

an independent indicator to be analysed alongside the latent drought factors, enabling targeted assessment of drought impacts on vegetation conditions.

A similar approach was applied to the heatwave indicator. While excluded from the latent drought model, heatwave remains a standalone shock indicator within the SMI, allowing its effects to be monitored independently without distorting the underlying drought severity structure.

**Figure 6: SMI updated drought analytical model**



## Needs Monitoring Framework (NMF)

As a core component of the RTM system, the Needs Monitoring Framework (NMF) provides a quarterly overview of sectoral and multi-sectoral humanitarian needs across Afghanistan. Designed to track the evolution of needs over time, NMF complements the Shock Monitoring Index (SMI) by capturing underlying vulnerabilities in the community, while SMI focuses on the occurrence and severity of shocks. Together, needs monitoring and shock monitoring enable humanitarian actors to identify areas at risk of deteriorating conditions and to inform timely, evidence-based response planning.

Given the strategic importance of NMF within the RTM system, a comprehensive methodological review of the framework has been conducted as part of the broader RTM system review. As previously outlined, the objectives of this review are to assess multicollinearity among indicators and to evaluate model fit and construct validity, ensuring that the NMF reliably captures sectoral and multi-sectoral humanitarian needs and remains analytically robust over time.

### NMF Model Review

The Needs Monitoring Framework (NMF) has been structured through continuous consultation between REACH, the Assessment and Analysis Working Group (AAWG), and humanitarian clusters during 2023–2024. Indicator selection was guided by these consultations to ensure sectoral relevance and alignment with coordination priorities. Previously, the primary objective of NMF was to support mid-year HNRP revisions; however, by providing quarterly updates on the evolution of needs across all districts, NMF outputs can continue to be used for anticipatory action planning, early prioritisation, and pre-positioning of resources in response to shifting needs.

The NMF currently comprises 29 indicators, approximately 90 percent of which are sourced from the quarterly HSM KI survey. Prior to the RTM system review, NMF indicators were assessed against the findings of the REACH Area of Knowledge (AoK) validation studies, and indicators identified as unsuitable for KI-level measurement or providing limited analytical value were excluded. Building on these refinements, the current system review focuses on assessing multicollinearity among remaining indicators and evaluating model fit and construct validity, to ensure that the NMF remains analytically robust and fit for purpose.

## NMF Framework

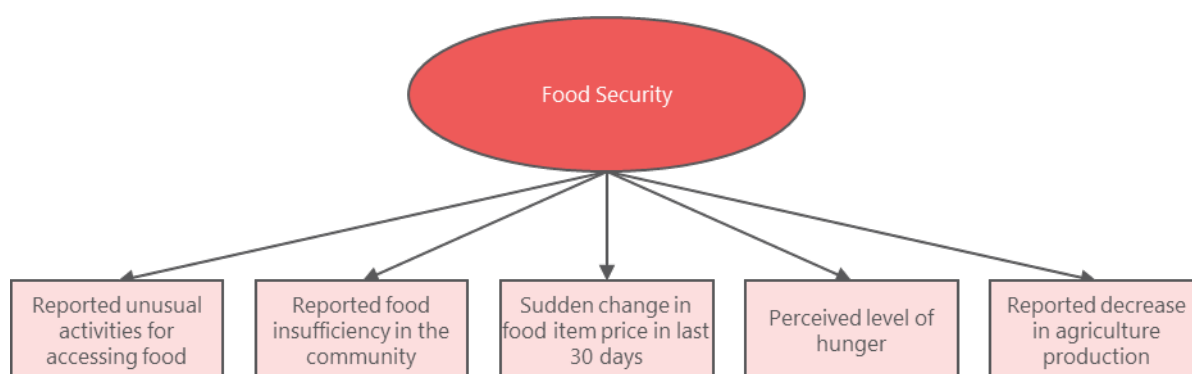
The NMF covers all seven humanitarian sectors in Afghanistan: Food Security, Emergency Shelter and Non-Food Items (ESNFI), Education, Health, Nutrition, Water, Sanitation and Hygiene (WASH), and Protection. A total of 29 indicators are grouped across these sectors.

Sector-level severity is first calculated for each sector based on the severity of its relevant indicators. The resulting sectoral severity scores are then aggregated to derive the multi-sectoral needs severity, in accordance with the Joint Intersectoral Analysis Framework (JIAF) 2.0 methodology.

### FOOD SECURITY

The Food Security sector within the NMF currently comprises five indicators. In earlier iterations of the framework, the FSL sector included ten indicators; however, based on findings from the Area of Knowledge (AoK) validation study, indicators for which key informants were unable to provide sufficiently reliable information were excluded.

**Figure 7: NMF food security analytical model**



To further strengthen the analytical robustness of the current model, the remaining indicators were reviewed through multicollinearity assessment and model fit evaluation, ensuring that the sector-level specification is both statistically sound and conceptually coherent.

### Multicollinearity Check

A multicollinearity assessment was conducted for the Food Security indicators using the Variance Inflation Factor (VIF). The results indicate no evidence of serious multicollinearity among the variables included in the current model, confirming that all five indicators can be retained without compromising model stability.

The regression specification used for the VIF assessment is as follows:

$$\text{Food Security}_i = \beta_0 + \beta_1 \text{Variable1}_i + \beta_2 \text{Variable2}_i + \beta_3 \text{Variable3}_i + \beta_4 \text{Variable4}_i + \beta_5 \text{Variable5}_i + \varepsilon_i$$

**Table 10: NMF food security multicollinearity assessment**

Variable	VIF	Multicollinearity Rating
Unusual activities reported for accessing food	1.01	No multicollinearity
Food insufficiency reported in the community	1.48	No multicollinearity
Sudden change in food item price in last 30 days	1.06	No multicollinearity
Perceived level of hunger reported by KIs	1.27	No multicollinearity
Decrease in Agriculture production reported	1.19	No multicollinearity

### Confirmatory Factor Analysis (CFA)

The Confirmatory Factor Analysis (CFA) results indicate an excellent model fit for the current Food Security and Livelihoods (FSL) measurement model, supporting the validity of a single latent construct underlying the selected indicators.

The CFA specification is as follows:

$$FSL_i = \lambda_1 \text{Variable1}_i + \lambda_2 \text{Variable2}_i + \lambda_3 \text{Variable3}_i + \lambda_4 \text{Variable4}_i + \lambda_5 \text{Variable5}_i + \varepsilon_i$$

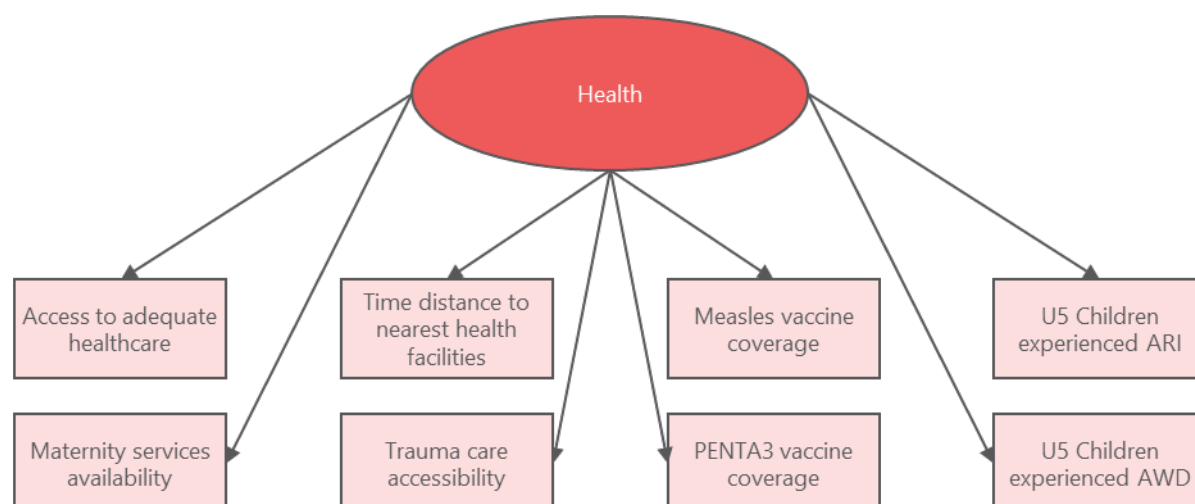
**Table 11: CFA model fit indices for the NMF food security model**

Index	Value	Interpretation
$\chi^2$ (df = 5)	6.24 (p = 0.284)	Excellent absolute fit
CFI	0.993	Excellent fit (>> 0.95)
TLI	0.985	Excellent fit
RMSEA	0.025	Excellent fit (< 0.05)
SRMR	0.029	Excellent fit (< 0.05)

**Conclusion:** The confirmatory factor analysis demonstrates an excellent overall model fit. The chi-square test was non-significant ( $\chi^2(5) = 6.24$ ,  $p = 0.284$ ), indicating no evidence of model misfit. Incremental fit indices (CFI = 0.99; TLI = 0.99) substantially exceed conventional thresholds for good fit, while residual-based measures (RMSEA = 0.03; SRMR = 0.03) further confirm a very close correspondence between the model-implied and observed covariance structures. Collectively, these results indicate that the specified model provides a robust and well-fitting representation of the underlying data structure and is appropriate for subsequent analysis

## HEALTH

The health sector within the NMF comprises eight indicators, capturing key dimensions of health needs, including access to health services, vaccination coverage, and disease outbreak risks, as reported through KI-level data.

**Figure 8: NMF health sector analytical model**

### Multicollinearity Check

A multicollinearity assessment for the Health sector indicators within the NMF was conducted using the Variance Inflation Factor (VIF). The results indicate no evidence of serious multicollinearity among the eight indicators included in the model.

The regression specification used for the VIF assessment is as follows:

$$\text{Health Need}_i = \beta_0 + \beta_1 \text{Variable1}_i + \beta_2 \text{Variable2}_i + \beta_3 \text{Variable3}_i + \dots + \beta_8 \text{Variable8}_i + \varepsilon_i$$

**Table 12: NMF health sector multicollinearity assessment table**

Variable	VIF	Multicollinearity Rating
Access to Adequate healthcare	1.42	No multicollinearity
Maternity services availability	1.33	No multicollinearity
Time distance to nearest health facilities	1.26	No multicollinearity
Trauma care accessibility	1.22	No multicollinearity
Measles vaccine coverage	1.29	No multicollinearity
PENTA3 vaccine coverage	1.28	No multicollinearity
Children U5 experienced AWD	1.03	No multicollinearity
Children U5 experienced ARI	1.03	No multicollinearity

### Confirmatory Factor Analysis (CFA)

Following confirmation that no serious multicollinearity exists among the indicators, a Confirmatory Factor Analysis (CFA) was conducted to assess whether the Health sector measurement model demonstrates an acceptable level of fit. The model specifies a single latent health need construct, with all eight indicators loading freely onto the latent factor.

The CFA specification is as follows:

$$\text{Health Need}_i = \lambda_1 \text{Variable1}_i + \lambda_2 \text{Variable2}_i + \dots + \lambda_8 \text{Variable8}_i + \varepsilon_i$$

**Table 13: CFA model fit indices for the NMF health model**

Index	Value	Assessment
$\chi^2$ (df = 20)	208.21 (p < 0.001)	Very strong evidence of misfit
CFI	0.518	Unacceptable (< 0.90)
TLI	0.326	Unacceptable
RMSEA	0.153	Severe misfit (> 0.10)
SRMR	0.106	Poor fit (> 0.08)

**Conclusion:** The confirmatory factor analysis indicates a poor model fit. The chi-square test was highly significant ( $\chi^2(20) = 208.21$ ,  $p < 0.001$ ), providing strong evidence that the specified model does not adequately reproduce the observed covariance structure. All complementary fit indices further support this conclusion, with very low incremental fit (CFI = 0.52; TLI = 0.33) and substantial residual misfit (RMSEA = 0.15; SRMR = 0.11). Taken together, these results suggest that the hypothesised factor structure is not supported by the data.

### Exploratory Factor Analysis (EFA)

Given that the Confirmatory Factor Analysis (CFA) indicated a poor model fit, an Exploratory Factor Analysis (EFA) was subsequently conducted to identify a more appropriate underlying factor structure and to inform model re-specification. A maximum likelihood factor analysis was applied to the full set of health sector indicators. The number of latent factors was determined through inspection of the scree plot, which suggested a three-factor solution.

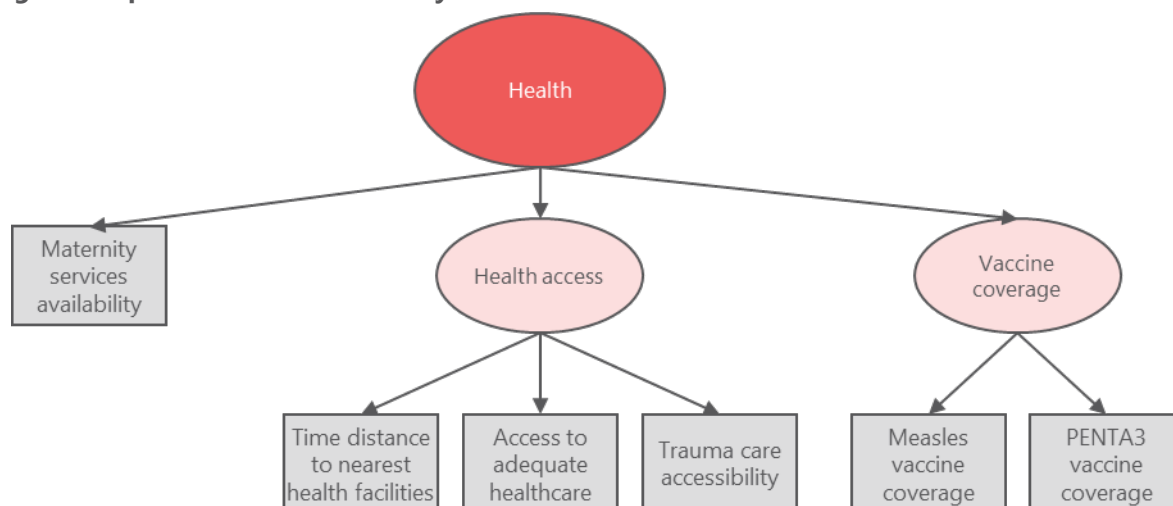
**Table 14: NMF health sector indicators factor loading**

Variable	ML2	ML1	ML3
Access to Adequate healthcare	0.03	0.12	0.68
Maternity services availability	0	1	0.01
Time distance to nearest health facilities	-0.06	0.27	0.32
Trauma care accessibility	-0.03	-0.13	0.64
Measles vaccine coverage	1	0.01	-0.01
PENTA3 vaccine coverage	0.42	-0.12	0.11
U5 Children experienced AWD	0.03	0.12	0.01
U5 Children experienced ARI	-0.14	-0.1	0.04

The EFA results are presented in Table 14. Of the eight indicators included in the analysis, two indicators—children under five experiencing acute watery diarrhoea (AWD) and children under five experiencing acute respiratory infection (ARI)—exhibited very low factor loadings across all factors, indicating limited contribution to the latent constructs.

**Conclusion:** The EFA results suggest a revised structure comprising two multi-indicator latent factors and one single-indicator factor. Two indicators—Children under five experienced ARI and Children under five experienced AWD—were excluded from the latent measurement model due to consistently low factor loadings. Conceptually, these excluded indicators reflect shock-related health outcomes rather than underlying health needs. As such, they are better treated as standalone shock indicators and can be integrated independently into the final health severity framework to support monitoring of areas experiencing acute health shocks alongside structural health needs.

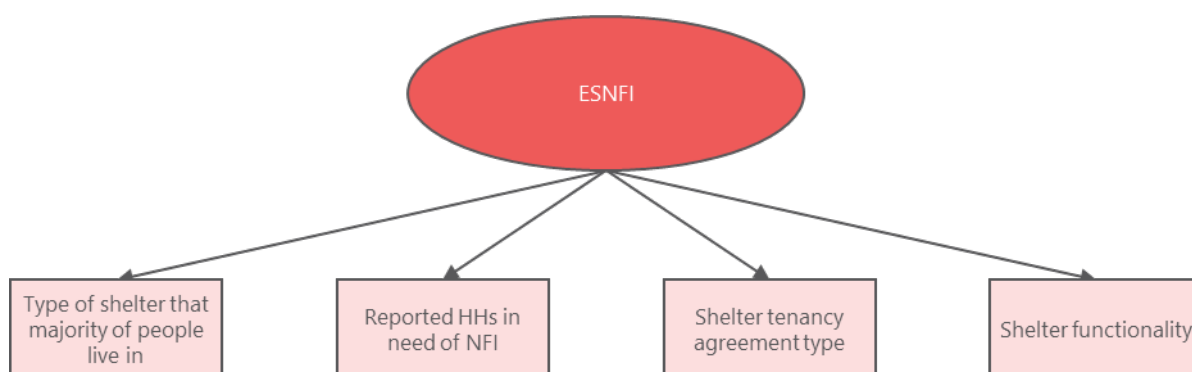
**Figure 9: Updated NMF Health analytical model**



**EMERGENCY SHELTER AND NON-FOOD ITEMS (ESNFI)**

The Emergency Shelter and Non-Food Items (ESNFI) sector within the NMF comprises four indicators capturing information on shelter conditions, shelter-related needs, and non-food item (NFI) needs at the community level. Consistent with the approach applied to other sectors, the ESNFI indicators were assessed through multicollinearity analysis and model fit evaluation to ensure analytical robustness.

**Figure 10: NMF ESNFI analytical model**



**Multicollinearity Check**

Based on the Variance Inflation Factor (VIF) assessment, no evidence of serious multicollinearity was detected among the indicators in the model.

$$ESNFI\ Need_i = \beta_0 + \beta_1 Variable1_i + \beta_2 Variable2_i + \beta_3 Variable3_i + \beta_4 Variable4_i + \varepsilon_i$$

**Confirmatory Factor Analysis**

To assess model fit, a Confirmatory Factor Analysis (CFA) was conducted for the ESNFI sector model. The results are presented below.

$$Health\ Need_i = \lambda_1 Variable1_i + \lambda_2 Variable2_i + \dots + \lambda_8 Variable8_i + \varepsilon_i$$

**Table 15: CFA model fit indices for the NMF ESNFI model**

Index	Value	Interpretation
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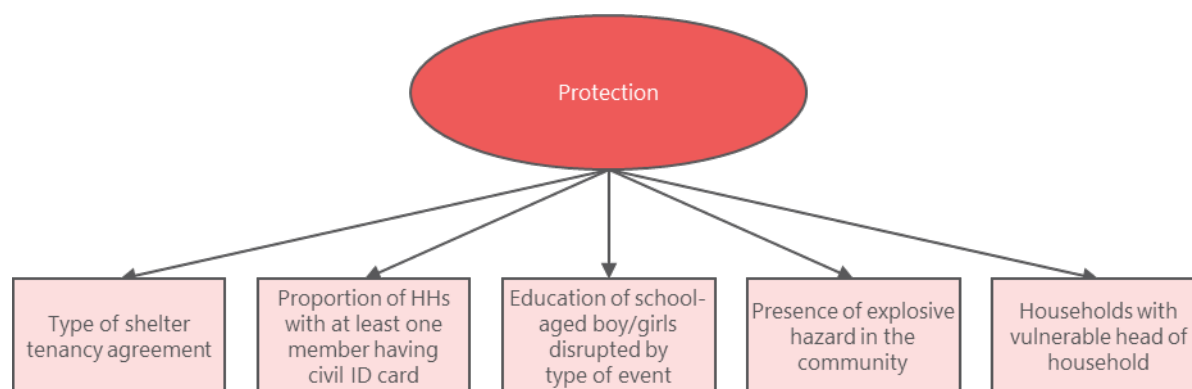
$\chi^2$ (df = 2)	0.16 (p = 0.921)	Excellent absolute fit
CFI	1	Perfect comparative fit
TLI	2.419	Not an error, but a known artifact
RMSEA	0	Perfect fit
SRMR	0.006	Excellent fit

**Conclusion:** The confirmatory factor analysis of the ESNFI construct demonstrates an excellent model fit. The chi-square test was non-significant ( $\chi^2(2) = 0.16$ ,  $p = 0.921$ ), indicating no evidence of model misfit. Comparative and residual-based fit indices further confirm this result, with a perfect CFI (1.00), a zero RMSEA, and a very low SRMR (0.006). The elevated TLI value reflects a known artefact that can occur in very well-fitting models with small degrees of freedom and does not indicate a specification error. Overall, the results suggest that the ESNFI latent construct is well represented by the selected indicators and is suitable for inclusion in the final needs severity framework.

## PROTECTION

The Protection sector within the NMF comprises five indicators designed to proxy protection-related needs at the community level.

**Figure 11: NMF protection section analytical model**



## Multicollinearity Check

A multicollinearity assessment for the Protection sector indicators was conducted using the Variance Inflation Factor (VIF). The results indicate no evidence of serious multicollinearity among the five indicators included in the model. The regression specification used for the VIF assessment is as follows:

$$\text{Protection Need}_i = \beta_0 + \beta_1 \text{Variable1}_i + \beta_2 \text{Variable2}_i + \beta_3 \text{Variable3}_i + \beta_4 \text{Variable4}_i + \beta_5 \text{Variable5}_i + \varepsilon_i$$

**Table 16: NMF Protection sector multicollinearity assessment table**

Variable	VIF	Multicollinearity Rating
Type of shelter tenancy agreement	1.09	No multicollinearity
Proportion of HHs with at least one member has civil ID card	1.13	No multicollinearity
Education of school aged boy/girls disrupted by type of event	1.13	No multicollinearity
Presence of explosive hazard in the community	1.01	No multicollinearity
Households with vulnerable head of household	1.03	No multicollinearity

According to the VIF measure, there is no serious multicollinearity among the indicators in the protection construct.

## Confirmatory Factor Analysis (CFA)

Following confirmation that no problematic multicollinearity exists among the indicators, a Confirmatory Factor Analysis (CFA) was conducted to assess whether the Protection sector measurement model demonstrates an acceptable level of fit. The model specifies a single latent protection need construct, with all indicators loading freely onto the latent factor.

The CFA specification is as follows:

$$\text{Protection Need}_i = \lambda_1 \text{Variable1}_i + \lambda_2 \text{Variable2}_i + \dots + \lambda_8 \text{Variable5}_i + \varepsilon_i$$

**Table 17: CFA model fit indices for the NMF protection model**

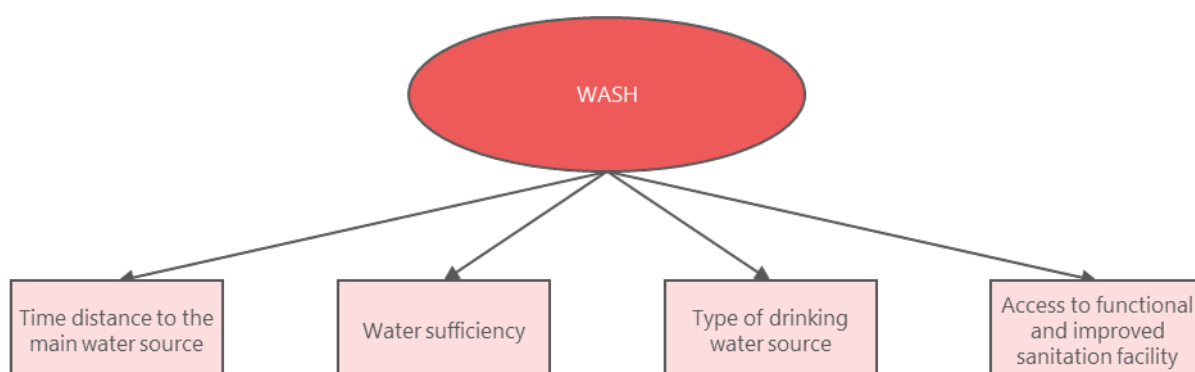
Fit index	Value	Interpretation
$\chi^2$ (df = 5)	2.873 (p = 0.719)	Excellent absolute fit
CFI	1	Perfect incremental fit
TLI	1.06	>1 → very strong fit (can occur with small df)
RMSEA	0	Excellent
SRMR	0.019	Excellent

**Conclusion:** The confirmatory factor analysis for the Protection construct demonstrates an excellent overall model fit. The chi-square test was non-significant ( $\chi^2(5) = 2.87$ ,  $p = 0.719$ ), indicating no evidence of model misfit. Incremental fit indices show perfect or near-perfect performance (CFI = 1.00; TLI = 1.06), while residual-based measures (RMSEA = 0.00; SRMR = 0.02) further confirm a very close correspondence between the model-implied and observed covariance structures. Overall, these results indicate that the selected indicators provide a robust and coherent representation of the Protection-Need construct and support its inclusion in the final needs severity framework.

## WASH

The Water, Sanitation and Hygiene (WASH) sector within the NMF comprises four indicators capturing key aspects of WASH-related needs at the community level. The WASH measurement construct is specified as follows.

**Figure 12: NMF wash cluster analytical model**



## Multicollinearity Check

A multicollinearity assessment for the WASH sector indicators was conducted using the Variance Inflation Factor (VIF), as outlined below.

$$\text{Wash Need}_i = \beta_0 + \beta_1 \text{Variable1}_i + \beta_2 \text{Variable2}_i + \beta_3 \text{Variable3}_i + \beta_4 \text{Variable4}_i + \varepsilon_i$$

**Table 18: NMF wash model multicollinearity assessment table**

Variable	VIF	Multicollinearity Rating
Time distance to the main water source	1.13	No multicollinearity
Water sufficiency	1.21	No multicollinearity
Type of drinking water source	1.03	No multicollinearity
Access to functional and improved sanitation facility	1.08	No multicollinearity

Based on the Variance Inflation Factor (VIF) assessment, the WASH indicators exhibit no evidence of multicollinearity

## Confirmatory Factor Analysis (CFA)

A Confirmatory Factor Analysis (CFA) was conducted to assess whether the WASH sector measurement model demonstrates an acceptable level of fit. The model specifies a single latent WASH need construct, with all four indicators loading freely onto the latent factor.

The CFA specification is as follows:

$$\text{WASH Need}_i = \lambda_1 \text{Variable1}_i + \lambda_2 \text{Variable2}_i + \lambda_3 \text{Variable3}_i + \lambda_4 \text{Variable4}_i + \varepsilon_i$$

**Table 19: CFA model fit indices for the NMF wash model**

Fit index	Value	Interpretation
$\chi^2$ (df = 2)	3.804 (p = 0.149)	Non-significant → good absolute fit
CFI	0.978	Excellent ( $\geq 0.95$ )
TLI	0.933	Acceptable–good
RMSEA	0.047	Good (< 0.05)
SRMR	0.028	Excellent (< 0.08; < 0.05 is very strong)

**Conclusion:** The confirmatory factor analysis for the WASH construct indicates a good overall model fit. The chi-square test was non-significant ( $\chi^2(2) = 3.80$ ,  $p = 0.149$ ), suggesting no evidence of absolute model misfit. Incremental fit indices demonstrate strong performance (CFI = 0.98; TLI = 0.93), while residual-based measures further support the adequacy of the model (RMSEA = 0.05; SRMR = 0.03). Taken together, these results indicate that the specified indicators provide a reliable and coherent representation of the underlying WASH-Need construct and support its inclusion in the final needs severity framework.

## NUTRITION

The Nutrition sector within the NMF comprises a single indicator: prevalence of Global Acute Malnutrition (GAM), derived from community-level nutrition and health screening data. As this sector is represented by a single observed indicator, no multicollinearity assessment or factor analysis was

conducted at this stage of the system review, since the indicator itself directly represents the latent nutrition need construct.

## EDUCATION

The Education sector within the NMF comprises two indicators. Given the limited degrees of freedom associated with a two-indicator specification, multicollinearity testing and Confirmatory Factor Analysis (CFA) were not applied, as such procedures are not statistically informative in this context.

## Conclusion

Given Afghanistan’s complex and protracted humanitarian context, and the need among response actors for timely, granular, and reliable data, the Real-Time Monitoring (RTM) system plays a critical and strategic role in supporting evidence-based decision-making. In recognition of this importance, a system review was conducted to assess the robustness of RTM’s underlying analytical models, focusing on multicollinearity among indicators and overall model fit. The findings of this review were subsequently applied to refine the RTM system models.

Multicollinearity assessments demonstrated that no serious multicollinearity exists across the reviewed models of NMF, QFSM, and SMI, with all indicators exhibiting acceptable levels of correlation. The absence of problematic multicollinearity is essential to ensure that no single dimension of need or shock is over-weighted in severity calculations, which could otherwise distort analytical outputs and misinform prioritisation and response decisions.

**QFSM models:** Confirmatory Factor Analysis (CFA) results indicate acceptable to excellent model fit across the QFSM framework. The three core food security dimensions—food access, food availability, and food utilization—as well as the two proxy-outcome-level indicators demonstrated satisfactory fit statistics. These results confirm that the current QFSM framework, comprising 19 indicators, constitutes a well-specified and statistically robust measurement model, with no evidence of structural misspecification.

**NMF sectoral models:** CFA was conducted across the seven NMF sectoral models: Food Security, WASH, ESNFI, Health, Nutrition, Protection, and Education. All sectoral models demonstrated acceptable to excellent fit, with the exception of the Health model. Initial CFA results for the Health sector indicated suboptimal fit, prompting a targeted model review informed by Exploratory Factor Analysis (EFA). Based on this review, two indicators (U5 AWD cases and U5 ARI cases) were excluded due to weak factor loadings and limited conceptual alignment with the latent construct. Following this refinement, the Health model demonstrated improved fit, and the total number of NMF indicators was reduced from 31 to 29, strengthening the overall coherence of the framework. The excluded indicators can instead be used as external shock exposure variables, in combination with Health sector need severity, to support the identification of health-related vulnerability.

**SMI drought component:** CFA results for the SMI drought component, which initially comprised seven indicators (SPI-3, accumulated precipitation at 6 and 12 months, snow water equivalent, early snow depletion, heatwave, and vegetation condition index) demonstrated poor model fit. This finding suggested that the indicators were capturing multiple underlying processes rather than a single latent construct. Subsequent EFA identified a revised structure comprising three distinct latent constructs: Meteorological Drought, Snow Conditions, and SPI-24 (long-term drought). In addition, the analysis indicated that Vegetation Condition Index (VCI) and heatwave indicators are more appropriately treated as external or contextual latent factors, rather than direct components of the drought construct. This refinement improves the conceptual clarity and analytical validity of the SMI drought framework.

### Meteoro-Hydrological Drought<sub>i</sub>

= Meteorological drought (SPI3 + Accum 6 + Accum 12)  
+ Snow Condition ( Snow water equivalent + Early Snow depletion) + SPI 24

**Overall Drought index<sub>i</sub>** = Meteoro-Hydrological Drought<sub>i</sub> + VCI<sub>i</sub>

Through the combined application of multicollinearity testing, Confirmatory Factor Analysis, and Exploratory Factor Analysis, the system review either validated the original model specifications or informed the development of revised models with improved factor structures and indicator groupings.

The resulting models demonstrate acceptable levels of fit and stronger conceptual alignment between indicators and latent constructs. This ensures that indicators used in severity calculations are both relevant and appropriately weighted, enhancing the precision and interpretability of RTM outputs in identifying needs and shock severity.

As RTM analytical products are already used by WFP, AAWG, and other response actors to inform planning and coordination, the improvements resulting from this system review strengthen the system's capacity to support a broader range of operational, programmatic, and strategic decision-making processes. By enhancing analytical robustness and precision, the revised RTM models further reinforce the system's role as a reliable decision-support and early warning tool, supporting prioritisation and targeted response in an increasingly complex humanitarian environment.