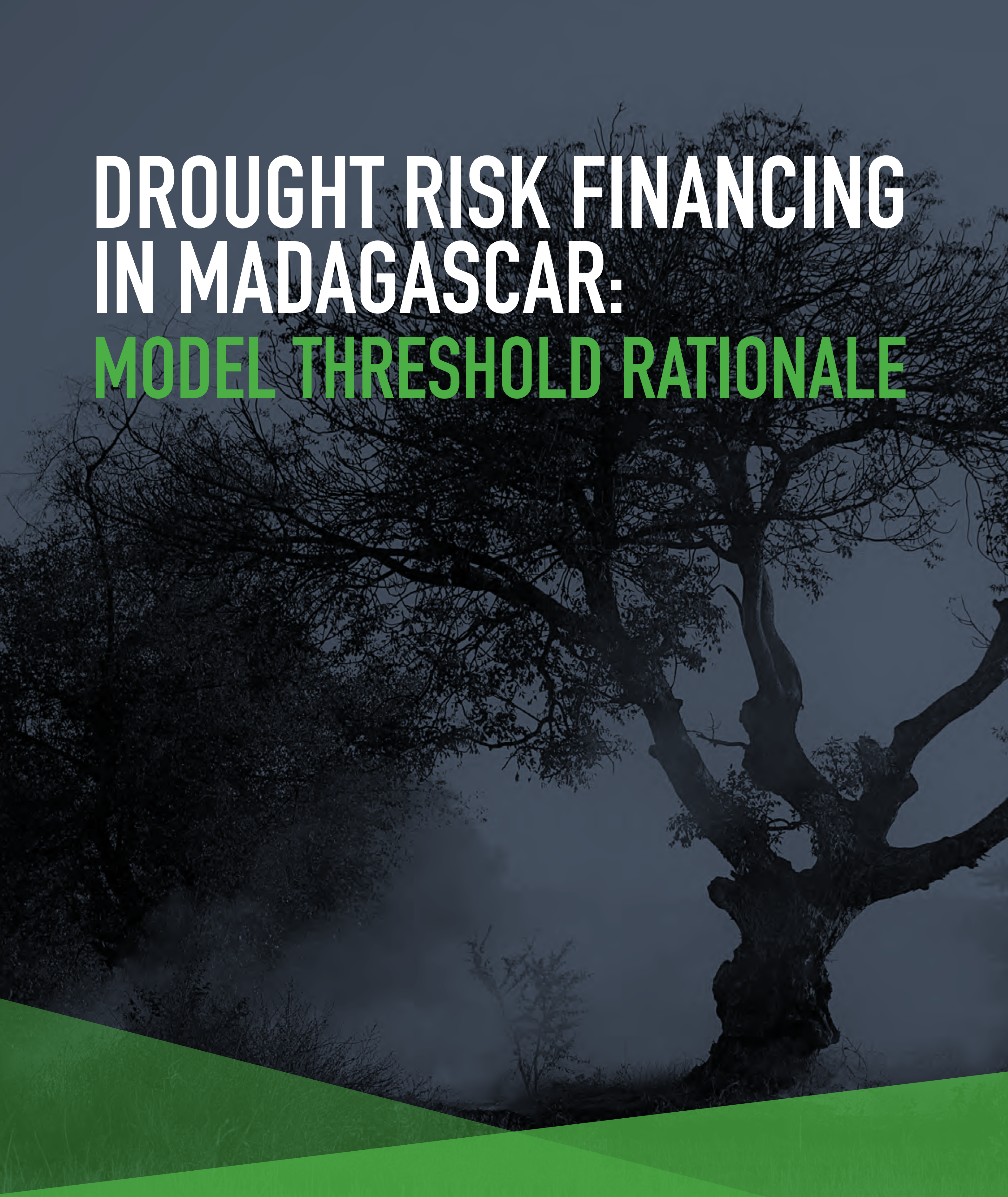
DROUGHT RISK FINANCING IN MADAGASCAR:
MODEL THRESHOLD RATIONALE



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START NETWORK

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01 BRIEF

The Madagascar drought Forecast-based Action (FbA) project aims to avert or at least minimise the negative effects of a drought on the forecasted food security of people at risk in selected geographical areas or communities. This document explains how the model and trigger system has been set up by Welthungerhilfe (WHH), including links to any analysis undertaken. For the system to link up the ***Start Financing Facility***, key recommendations have been advised by Start Network. The document has been co-written by WHH and Start Network. The model will be operationally run and monitored by WHH's Scientific Advisor throughout the trigger window period.

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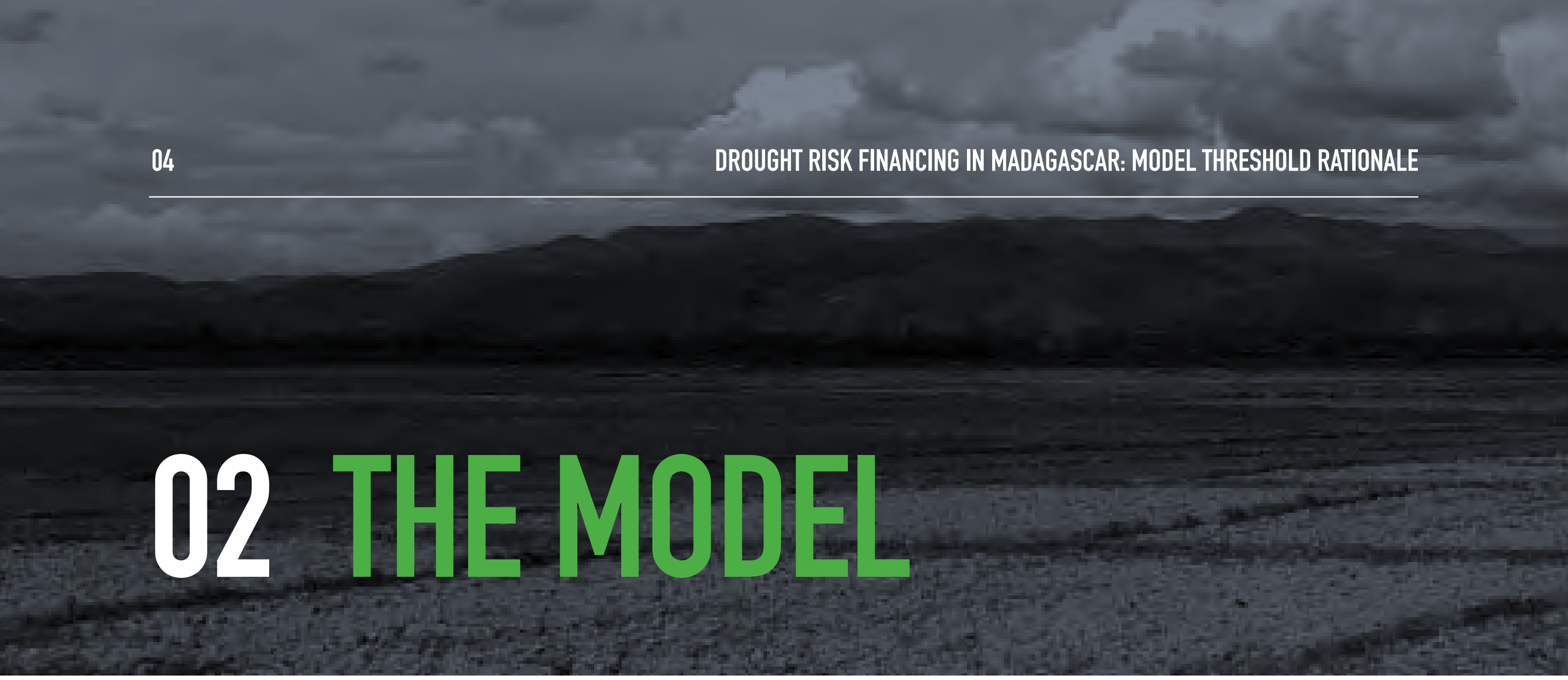


02 THE MODEL

DEFINITION

GeoWRSI is a geospatial model for estimating the climatic impact of water stress on a given crop. In other words, it is a free and autonomous software to calculate the water requirement satisfaction index water (WRSI) of a crop. It is implemented by the US Geological Survey (USGS) for the Famine Early Warning System Network (FEWS NET) activity.

REFERENCE CROP: UPLAND RICE

Within the framework of the Forecast-based Action (FbA) drought project, the crop selected as the reference crop is upland rice (cultivated without being submerged in a rice field).

The main reason for choosing upland rice is its dominance. Rice is a dominant crop for most of the entire Big Island regions. It is the main food crop and an important cash crop. The vulnerability of the Madagascar population to rice has motivated WHH to implement a FbA system. It should be noted that the rainfed rice cycle lasts an average of 120 to 150 days from semi to full maturity.

CHARACTERISTICS AND FUNDAMENTAL PRINCIPLES OF THE MODEL

The GEOWRSI model program runs a crop-specific water balance model for a selected region of the world using raster data entry. The results of the program can be used to help qualitatively assess and monitor crop conditions during the crop growing season or can be regressed with yields to develop yield estimation models and generate yield estimates and forecasts (*source:* ***https://www.chc.ucsb.edu/tools/geowrsi***)

The water balance assumptions relate to precipitation and water demand, and are as follows:

- √ If $SWS+(PPT-WR)>0$: no water deficit (WRSI=100)
- √ If $SWS+(PPT-WR)<0$: water deficiency identified

  SWS : Soil water supply
  PPT : Precipitations
  WR : Water requirement

Before running GeoWRSI, a number of parameters must be specified, according to the region and the crop being monitored. These parameters are:

- **Decades of the beginning and end of the growing season** may be specific according to the regions. In the case of Madagascar these dates correspond on average in the whole island from the 28th to the 15th decade (October - May) of the following year for the rice.

- **Resolution of the data used:** depends on the resolution of the data that is used and available. Especially for Madagascar FbF project, we used merged rainfall data (Satellite data x observed rainfall data) with 0.0375° x 0.0375° of resolution that is approximatively 4km x 4km.
- **Definition of the semi effective date** which according to the FAO is "the period when the rainy season is most likely to continue without major interruption". This is a parameter that need to be specified in the model. It is the minimum rainfall required to effectively start the crop season. The model's semi-effective default date[1] is as follows:
  - 1st dekad with cumulative rainfall of 25mm[2]
  - followed by 2nd and 3rd dekad with cumulative rainfall of 20mm.
- **The length of the vegetative cycle** of the crop in decades. Since rice has been taken as reference crop, the average cycle length is 160 days that is **16 decades**.
- **Types of climatic data used.** We need two main parameters to run the GeoWRSI model, rainfall, and potential evapotranspiration. For the rainfall data, satellite data is merged with station data. For the potential evapotranspiration data, in the case of Madagascar, climatological data is used from the national meteorological department.

MAIN PARAMETERS CONSIDERED IN THE MODEL

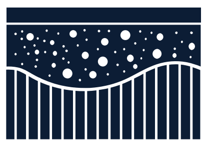
The GeoWRSI is one of the few models that considers 3 major elements:

01

PARAMETERS CONCERNING PLANTS:

- Effective date of the semi in decade
- Length of the vegetative cycle
- Cultural coefficient (Kc)

02



SOIL PARAMETER:

- Soil water retention capacity

03

METEOROLOGICAL PARAMETERS:

- Decadal Precipitation
- Potential decadal evapotranspiration

1 These default dates the recommended values according to the DGM and have been validated by the DGM.
2 WHH have confirmed that these e parameters have been validated by the DGM, who are also using them to monitor agricultural drought at the national level. Please see the *Drought monitoring document* for more detail.

03 DATA USED

PRECIPITATION

For this project satellite data and observed precipitation data was used. Combining two types of datasets improves coverage and resolution of the GeoWRSI model output. The technical characteristics of these data are as follows:

TABLE 1: PRECIPITATION DATA CHARACTERISTICS

PRECIPITATION DATA	TYPES	RESOLUTION	PERIOD	SOURCE
RFE2	DAILY DATA	0.1° X 0.1°	2001 - PRESENT	SATELLITE (*NOAA WEBSITE*)
REAL STATION DATA	DEKADAL DATA	0.0375° X 0.0375°	1983 - PRESENT	*DGM*

WHY WAS RFE2 DATA SELECTED?

There are several types of satellite data sets available online (CHIRPS, RFE2, ARC2, TAMSAT). The Directorate General of Meteorology performed a ***correlation assessment*** of the available satellite data against the real time station data. RFE2 was chosen because it has the highest correlation with real station data for Madagascar (see table 2 below).

RFE2 is a satellite dataset provided by FEWS NET and sourced by the National Oceanic and Atmospheric Administration (NOAA), RFE2 data is available from 2001 (***NOAA website***).

TABLE 2: THE CORRELATION FOR RFE2 AND ARC2 WITH REAL TIME STATION DATA

DATA SETS	PERIOD OF THE ASSESSMENT	PERCENTAGE OF CORRELATION WITH REAL STATION DATA
RFE2	2001 - 2017	**76.2%**
ARC2	1981 - 2017	**58%**

EVAPOTRANSPIRATION

For evapotranspiration data, the FbA approach uses climatological data provided by the DGM to run the model.

TABLE 3: EVAPOTRANSPIRATION DATA CHARACTERISTICS

PARAMETER	TYPE	PERIOD	SOURCE
EVAPOTRANSPIRATION	CLIMATOLOGICAL DATA	1981 - 2019	*DGM*

THE LOCATIONS MONITORED

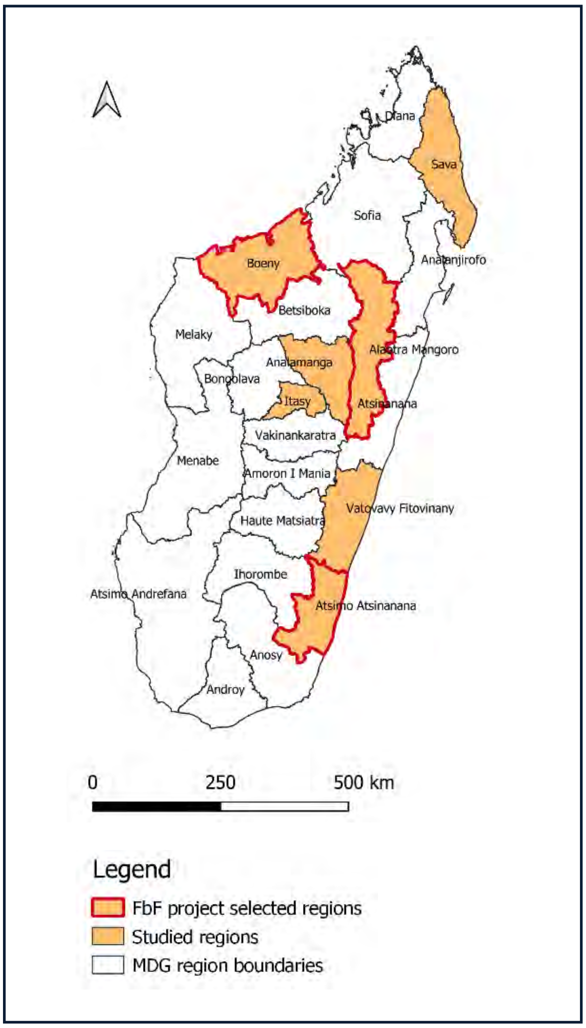
The criteria for assessing which locations are most suited for targeted action can be numerous. The necessary criteria used to assess the monitored locations were:

- **Climatological aspects** such as: vulnerability to drought, rainfall situation and the seasonal rainfall forecast to understand and confirm the regional choice
- **Strategical aspects** such as: choosing geographically non-contiguous areas, other than the Great South to ensure the relevance and duplicability of the mechanism

According to the above criteria, several regions were classed as having a possible risk of drought: Analamanga, Itasy, Alaotra Mangoro, Atsimo Atsinanana, Vatovavy Fitovinany, Boeny and SAVA. To detect which regions were most vulnerable to drought, the SPI6 (or Standardized Precipitation) and the WRSI indexes were analysed (view full analysis *here*).

Following this analysis, three regions were selected as the beneficiates of the 2021 FbA project: **Alaotra Mangoro** (in the Eastern part), **Atsimo Atsinanana** (in the Southeast) and the **Boeny region** (in the Northwest).

The map outlines the 6 study regions, with the three selected regions outlined in red.



04 THRESHOLD ANALYSIS

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The model outputs the WRSI End Of Season (WRSI_EOS) index which indicates the satisfaction of water rice needs at the end of the season.[3]

Using historical WRSI_EOS values, the lowest WRSI_EOS value was identified over a ten-year period (2007-2018),[4] for each district. These values were then triangulated and confirmed with local (farmers) perceptions. Depending on the local experiences of rainfall deficit and given the variable climatology of different regions, drought intensity thresholds are likely to vary across different regions.

Farmers identified the 2016/2017 season as the most extreme drought year, for all districts. This aligns with historical WRSI_EOS data, with the 2016/2017 season receiving the lowest WRSI value in the last 10 years - except for the Boeny region. For the Boeny districts: Majunga II and Marovary, 2014/2015 and 2012/2013 had the lowest WRSI_EOS value respectively. However, farmers' perceptions still state 2016/2017 as the worst drought year in this region.[5]

Therefore, according to the ***analyses*** carried out by the Technical Working Group (Direction Générale de la Meteorology, WHH Forecast-based Action team, Bureau National de Gestion des Risques et Catastrophes), with the support of the local technicians, the following thresholds for each region are as follows:

TABLE 5: WRSI_EOS THRESHOLDS*

REGIONS	DISTRICTS	VALUES WRSI
ALAOTRA MONGORO	AMPARAFARAVOLA AMBATONDRAZAKA	61
ATSIMO ATSINANANA	FARAFANGANA VANGAINDRANO	61
BOENY	MAHAJANGA II MAROVOAY	63

***which represent the level at which farmers begin to feel the negative impact of rainfall deficiency on their daily activities.**

Note that these thresholds were not defined using any specific function or formula. They were based on analysing the End Of Season historical WRSI figures, which were then triangulated and confirmed with local perceptions.

VALIDATION – START NETWORK

In order to validate these thresholds, Start Network advises WHH to provide and perform these analyses using the weekly WRSI historic values over the monitoring period. This will not only allow others to see the data the trigger is being design for – for transparency – but also to 1) validate the end of season values as a return period, 2) to validate against other forecasting models (e.g. TASMAT, ARC2) and 3) enable the necessary analysis for the FbA system to be attached to the SFF (see section below).

3 The model can also give the projected state of satisfaction of water rice needs before the end of the season is over.
4 Local communities' have argued that the last ten years have been the more severe drought years (which is supported by the historical WRSI_EOS).
5 This year corresponded to a moderate WRSI_EOS value.

A validation exercise of the GeoWRSI model would also be worthwhile, testing the skill of the model against observed drought and impact data.

FREQUENCY - START NETWORK

It should be noted that no probabilities can be calculated from theses WRSI values at present. This is because the historical index does not marry up precisely to the triggering set up. At the moment, the historical index is the end of season average across the whole rainy season (with farmers input to define the damaging WRSI level), the triggering index is for the cultivation period only. These two will have a different statistical historical pattern. Start Network agrees that this is an acceptable triggering approach for this pilot FbA year, however, in order to quantify the risk (i.e. calculating the frequency of pay-out in any one year) an historical index is needed for the period the trigger value is calculated from (and monitored during the live system). This will allow the system to be attached to the Start Finance Facility (SFF). The SFF uses the statistical historical pattern to identify how likely a pay-out will be in any one year, which allows the financial risk to be managed and pay-outs to be guaranteed and triggered sustainably.

Building out the historical WRSI for the monitoring period should be completed by WHH before September 2021, ensuring time for validation and aligning longer term financing to the SFF.

05 VULNERABILITY

The Household Economic Analysis (HEA) is a livelihood-based approach to assessing the vulnerability of the at risk population. A HEA is therefore based on:

- **Determining "livelihood zones" (LZs) where people share broadly the same coping strategies.**
- **Decomposition of the population into socio-economic classes**
- **Basic access to food and income**
- **The ability of households to respond to a hazard**
- **Dependence of populations on external aid to survive and/or maintain their livelihoods.**

The vulnerability values are from the Baseline excel sheet provided as result of the HEA analysis (BSS) and they are obtained there for 4 wealth categories thus Very poor, Poor, Average and Rich. The following formula is used to obtain the HEA scores:

$$\textit{HEA scores} = \frac{\textit{Total Income}}{\textit{Livelihood protection threshold}}$$

See in the *BSS* excel sheet - in the "GRAPHS" sheet, line 273 and 271 for the figures

	BOENY	ALAOTRA	ATSIMO ATSINANAN
RICH	1,49	1,59	1,83
AVERAGE	1,32	1,38	1,60
POOR	1,12	1,22	1,28
VERY POOR	1,05	1,10	1,21
WEIGHTED AVERAGE	1,22	1,26	1,39

EAP Validation Ambatondrazaka.


Group at the workshop for validation of FBA common framework

To obtain each regions standard Vulnerability Indicator value (scale from 0 to 1), the HEA scores needed to be normalised. This is because the values from the ***Baseline Storage Spreadsheet (BSS)*** were not in the range of 0 to 1 (see appendix for more information).

The formula used to normalise values ranged from 0 to 1 is:

$$X_{i,0\ \text{à}1} = \frac{X_i - X_{Min}}{X_{Max} - X_{Min}}$$

$X_{i,0\ \text{à}1}$ = the new value you wish to calculate, normalized value
X_i = individual data point to be transformed
X_{Min} = the lowest value of that indicator
X_{Max} = the highest value of that indicator

Source: *The Vulnerability Sourcebook*, Concept and guidelines for standardized vulnerability assessments, GIZ [2017]

Using the following minimum and maximum, the calculation process is summarized below in table 6.

BOENY	ALAOTRA	ATSIMO ATSINANAN
MIN = 1.05	MIN = 1.1	MIN = 1.21
MAX = 1.49	MAX = 1.59	MAX = 1.83

TABLE 6: NORMALISATION HEA SCORES FOR VULNERABILITY VALUES

REGIONS	WEALTH CATEGORIES	HEA SCORE From BSS outcome analysis	HEA WEIGHTED AVERAGE*	0 TO 1 NORMALIZATION**
BOENY	VP P M R	1.05 1.12 1.32 1.49	1.22	0.38
ALAOTRA	VP P M R	1.1 1.22 1.38 1.38	1.26	0.32
ATSIMO ATSINANA	VP P M R	1.21 1.28 1.6 1.83	1.39	0.29

* Using the proportion of population for each wealth category given in the HEA analysis
** Final vulnerability scores to use

The ***WHH HEA*** normalized values calculated in the table above were used in the WHH trigger calculation, by multiplying the vulnerability score (vulnerability of the community) with the WRSI thresholds (intensity of impact). If a WRSI of 100 is considered as the optimal situation, the difference between this and the observed value of WRSI (or WRSI threshold) is the impact relative to the optimal situation.

Therefore, to set a threshold impact value, the equation used is as follows:

Threshold = [100 - *WRSI threshold value*] x *HEA vulnerability values*

To estimate the current impact of drought per decade, the following equation is used

Impact = [100 - *WRSI dekadal monitering value*] x *HEA vulnerability values*

To view the trigger sheet please view ***HERE!***
https://docs.google.com/spreadsheets/d/1vTpAKPFeClSC_XdEsw_ehIF67iH1ejtMNBMCYi8NpC8/edit#gid=839209815 WRSI values are manually updated by WHH's Scientific Advisor.

The 'distance from impact' decides if the system is observation, warning or activation state. In another words, it is activated when the impact reaches the threshold. It is automatically calculated in the excel sheets of WHH's monitoring tool.

The formula is as follows:

Distance from threshold = *Threshold* - *Impact*

- Threshold – Impact > 5 = Observation
- Threshold – Impact is between 0 to 5 = Warning
- Threshold – Impact < 0 (negative value) = Activation

Start Network has advised WHH to factor in the HEA results (shown in Appendix 1), only once the WRSI triggers have been met or exceeded. The HEA informs how many vulnerable people are likely to be impacted for each

WRSI severity level and thus allows for immediate operational and financial response.

HEA 2021 FieldTrip

06 TRIGGER THRESHOLDS

IF ANY OF THE BELOW TRIGGER CONDITIONS ARE MET THE SYSTEM IS ACTIVATED AND FUNDS ARE RELEASED.

01

IF THE WRSI VALUE ARE BELOW 50 DURING THE SEEDING PERIOD

October & the end of January

02

IF THE WRSI VALUES ARE BELOW 50 DURING THE FIRST 2 DEKADS OF THE VEGETATION PERIOD

Roughly in January

03

IF THE WRSI VALUES ARE BELOW THE IMPACT THRESHOLD (shown in the table below) FOR 3 SUCCESSIVE DEKADS[6] DURING THE REPRODUCTIVE OR VEGETATION PERIOD

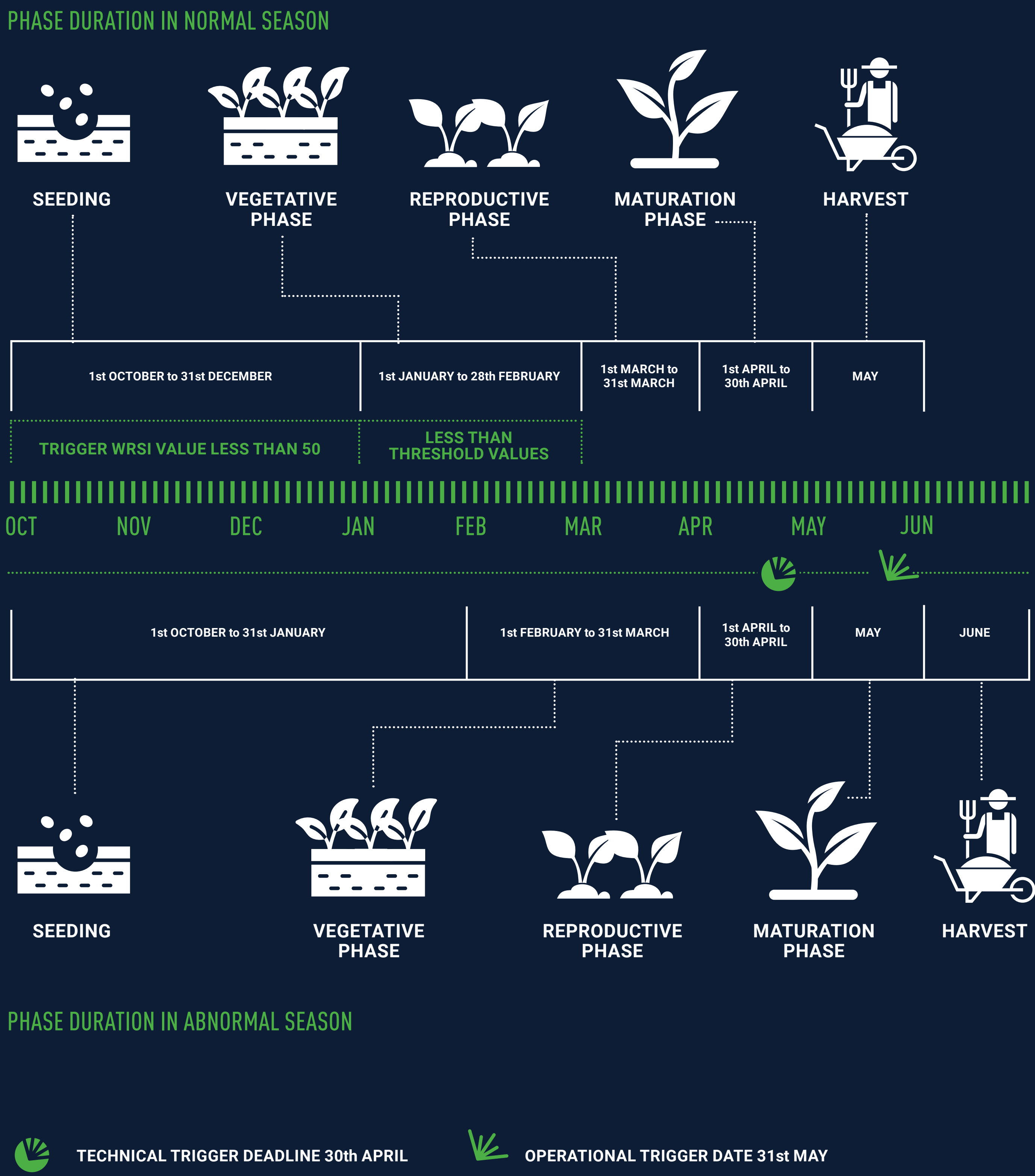
Roughly from January to March

TRIGGER CONDITION 03: IMPACT THRESHOLDS

REGIONS	DISTRICTS	THRESHOLDS IMPACT (HEA+WRSI)
ALAOTRA MONGORO	AMPARAFARAVOLA	80.48
	AMBATONDRAZAKA	80.48
ATSIMO ATSINANANA	FARAFANGANA	82.31
	VANGAINDRANO	82.31
BOENY	MAHAJANGA II	76.06
	MAROVOAY	76.06

6 The system is activated at the end of these 3 decades because there will most likely be adverse effects of this water deficit on production towards the end of the season. Very important to note is that even short dry periods during the sensitive phases of the rice crop can impact production.

THE LENGTH OF EACH CROP STAGE



07 TRIGGER FUNDS

The funding available for 2021 stands at 500,000 EUR. If thresholds are met, up to the full amount will be released according to the budget requested in the EAP presented by the EAP Custodians.

It is crucial to note that funds will not however be allocated until the end of the monitoring period (12th dekad). This is because there are 3 possible trigger periods, and the fact that each location triggers independently from the others.

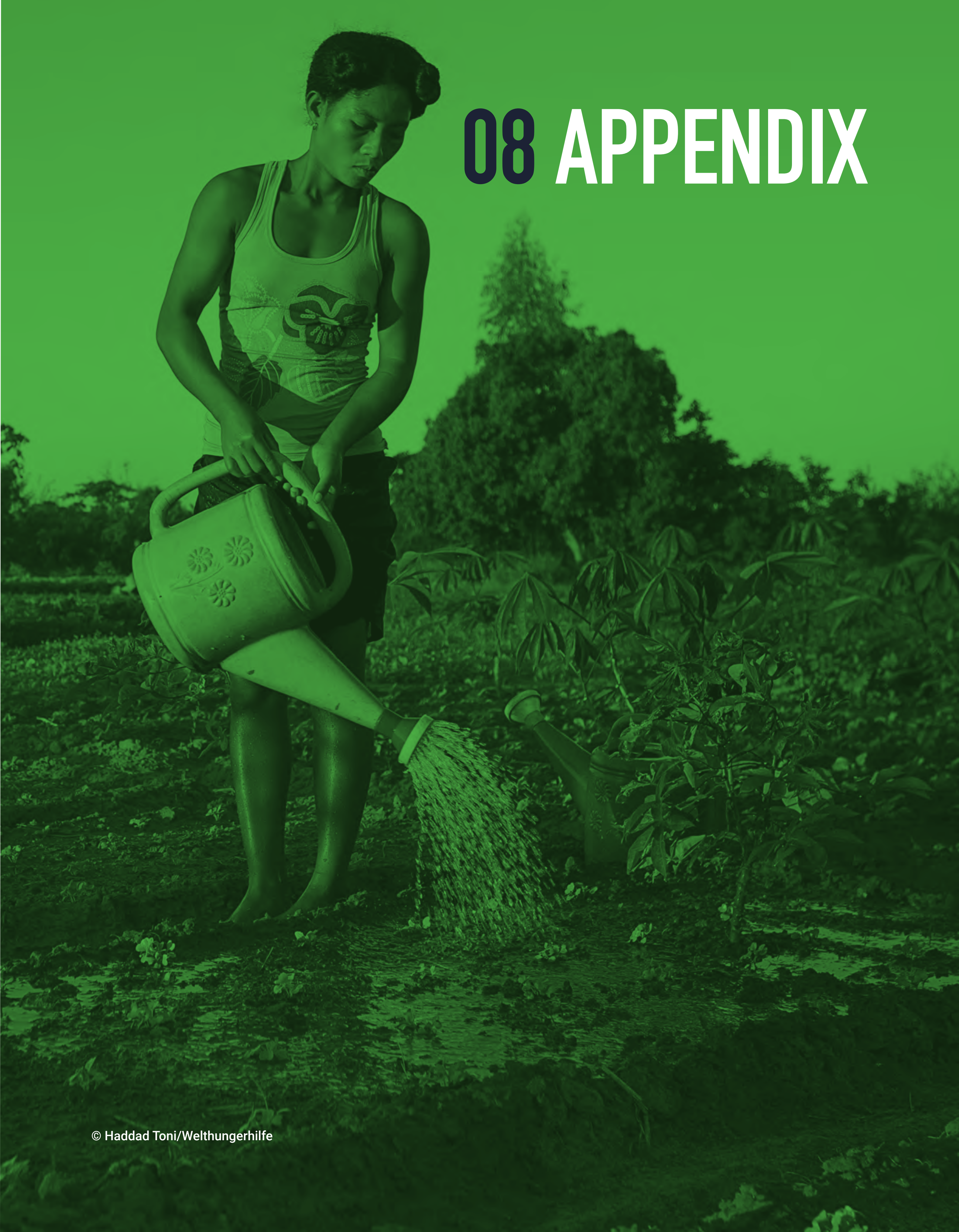
Therefore, if any of the trigger conditions are met in more than one location during the monitoring period, the payout will be split in the same ratio as the number of people needing assistance (using the EAPs and the HEA figures (displayed in appendix).

An example: Farfangana has 36,000 people at risk, with a WRSI of 60. The EAP requires 1 million euros to protect those people. In Marovoay, there has a severe drought below 40 WRSI with over 75,000 people in need of protection, requiring 3 million euros. In 2021 the available trigger pot is 500,000 euros. Therefore 68% of the funding is allocated proportionally based on need to Marovoay (340,000 euros), and 32% to Farfangana (160,000 euros).

The provision of this data and analysis to Start Network Technical and Operational Leads will be used to trigger the award letter to WHH of the 2021 pot.

Agro-meteorological observation stations

08 APPENDIX



The HEA calculates the number of people likely to be impacted from a drought event at different severity levels. HEA outcome analysis was completed for all 6 districts and will inform how many people are likely to be impacted for each WRSI severity level.

Numbers extracted from the HEA LIAS found ***here***

The total number of people at risk in all 6 districts are shown below. Currently operating under a $30 (US dollars) per head intervention cost assumption.

AMBATONDRA			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	130,015	$3,900,450
SEVERE	50-59	95,264	$2,857,920
MODERATE	60-70	38,413	$1,152,390
MILD	80-95	0	$0

AMPARAFARAVOLA			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	150,412	$4,512,360
SEVERE	50-59	94,788	$2,843,640
MODERATE	60-70	38,221	$1,146,630
MILD	80-95	0	$0

FARAFANGANA			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	66,909	$2,007,270
SEVERE	50-59	66,909	$2,007,270
MODERATE	60-70	35,951	$1,078,530
MILD	80-95	0	$0

VANGAINDRANO			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	106,755	$3,202,650
SEVERE	50-59	106,755	$3,202,650
MODERATE	60-70	57,361	$1,720,830
MILD	80-95	0	$0

MAHAJANGA II			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	51,702	$1,551,060
SEVERE	50-59	14,036	$421,080
MODERATE	60-70	14,036	$421,080
MILD	80-95	0	$0

MAROVOAY			
FUNDING TRIGGERING LEVELS	WRSI VALUE	TOTAL # PEOPLE AT RISK IN ALL DISTRICTS	TOTAL RESPONSE COST
EXTREME	0-49	75,332	$2,259,960
SEVERE	50-59	37,666	$1,129,980
MODERATE	60-70	37,666	$1,129,980
MILD	80-95	0	$0