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**Rainfall Intensity-Duration-Frequency
Analysis for Selected Parts of Eastern Oromia**

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1. INTRODUCTION

- Shortage of rainfall and the presence of it in abundance especially if not controlled have their consequences in every environment.
- Accurate prediction of return period enables the designers to prescribe the most **economical** structure consistent with public **safety**.
- In fact, the variability of rainfall in time and in space causes its occurrence very difficult to predict. Thus accepting a certain amount of risk that the capacity may be exceeded.

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- When we look at the situation in Ethiopia, the climate is characterized by high rainfall variability.
- The country is endowed with huge amount of water potential.
- A number of factors contribute to this under performance of water resource development.

■ The objectives were:

- ☞ to develop Intensity-Duration-Frequency curves;
and
- ☞ to establish mathematical relationships among intensity, duration, and frequency and generate parametric values for the study area.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

- ✂ The study area in this research work includes: Dengego, Dire Dawa, Gelemso, Haramaya, Harar and Miesso.
- ✂ Selection of these stations was based on the fact that these stations are all first class (automatic recording stations).

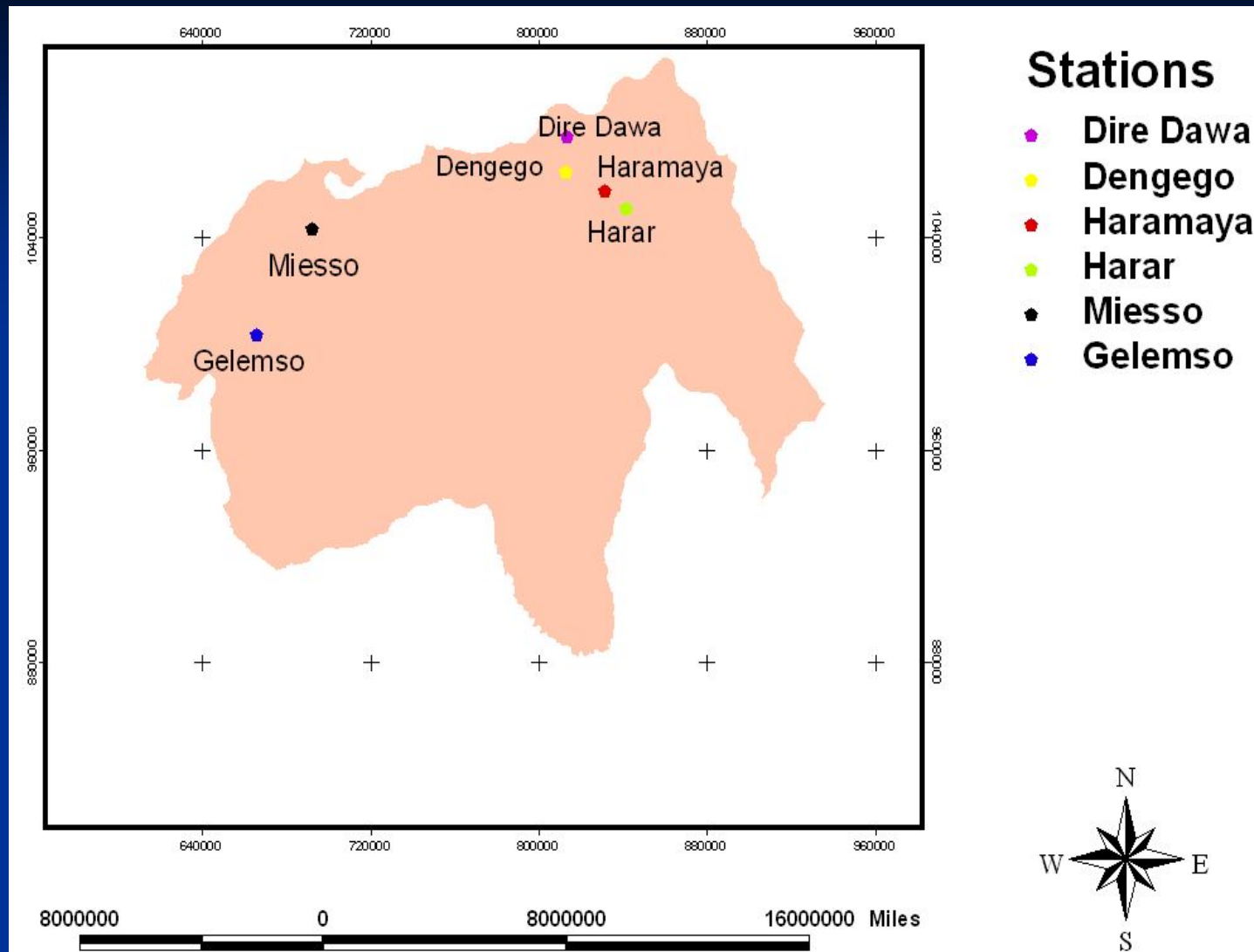


Figure 1. Location of study stations in eastern Oromia

Table 1. Station descriptive parameters

No.	Station code	Station name	Latitude ($^{\circ}N$)	Longitude ($^{\circ}E$)	Altitude (meters)
1	HADENG13	Dengego	9.19	41.28	2350
2	HADIRE12	Dire Dawa	9.36	41.51	1260
3	HAGELE11	Gelemso	8.49	40.31	1940
4	HAALEM11	Haramaya	9.26	42.01	2125
5	HAHARA31	Harar	9.18	42.10	2100
6	HAMEIS21	Meiso	9.14	40.45	1400

3.2. Steps of Data Collection Process

- ✂ Data source is the automatically recorded rainfall charts.
- ✂ The daily rainfall data were read for each station of some selected durations.
- ✂ The annual maximum rainfall values were then extracted from the daily rainfall data.
- ✂ Finally, the extracted annual maximum rainfall values were arranged in descending order.

3.3. Data Analysis and Fitting the Probability Distribution

✍ The annual maximum rainfall data were analyzed using the method of frequency analysis and applying mathematical relationships.

Testing the goodness of fit of data to the probability distribution function

✍ The chi-square goodness of fit test was applied to see the appropriateness of the selected probability distribution.

3.4. Computation of Extreme Value (x_T)

✎ The expected extreme value x_T for any return periods can be computed by using the following relationship:

$$y_T = \bar{y} + K_T S_y \quad \rightarrow \quad x_T = \text{antilog} \left(\bar{y} + K_T S_y \right)$$

3.5. Calculation of Rainfall Intensity (I)

✎ Rainfall intensity calculation was made by dividing the rainfall depth to their respective durations.

$$I = \frac{\text{Rainfall depth (mm)}}{\text{Time duration (hr)}} = \frac{x_T}{D_i}$$

3.6. Estimation of IDF Curve Coefficients

- ✍ The IDF Curve Fit Software was used to solve the IDF parameters (a , b and c) values of an Intensity-Duration-Frequency equation of the general form:

$$I = \frac{a}{(t_d + b)^c}$$

- ✍ Where I is rainfall intensity (mm/hr), t_d is rainfall duration (minute), a is coefficient with the same unit as I , b is time constant (minute) and c is an exponent usually less than 1.

3.7. Parameter Performance Testing

✂ The coefficient of determinations r^2 between the computed and observed intensity can be computed using the following form:

$$r^2 = \left(\frac{\sum_{i=1}^n (O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^n (O_i - \bar{O})^2} \sqrt{\sum_{i=1}^n (P_i - \bar{P})^2}} \right)^2$$

4. RESULTS AND DISCUSSION

4.1. Tests of Log Pearson Type III Distribution

Table 4.1. Calculated chi-square values

Station Name	Summary of Chi-Square Values for the Indicative Durations (hr)						
	0.5	1	2	3	6	12	24
Dengego		<i>6.84</i>	<i>11.35</i>	<i>7.52</i>	<i>11.32</i>	<i>3.10</i>	<i>5.26</i>
Dire Dawa	<i>2.31</i>	<i>4.96</i>	<i>6.19</i>	<i>4.26</i>	<i>5.44</i>	<i>7.83</i>	<i>10.86</i>
Gelemso	<i>4.91</i>	<i>3.93</i>	<i>2.12</i>	<i>2.63</i>	<i>1.30</i>	<i>1.37</i>	<i>1.39</i>
Haramaya	<i>5.68</i>	<i>2.45</i>	<i>3.77</i>	<i>5.83</i>	<i>4.60</i>	<i>5.60</i>	<i>5.30</i>
Harar	<i>4.27</i>	<i>3.10</i>	<i>2.55</i>	<i>4.32</i>	<i>5.61</i>	<i>2.15</i>	<i>1.35</i>
Miesso	<i>5.16</i>	<i>2.93</i>	<i>4.45</i>	<i>7.18</i>	<i>10.21</i>	<i>7.90</i>	<i>6.18</i>

Table 4.2. Tabulated chi-square values

Station Name	Summary of Chi-Square Values for the Indicative Durations (hr)							
	0.5	1	2	3	6	12	24	
Dengego		<i>11.07</i>	<i>12.59</i>	<i>9.49</i>	<i>12.59</i>	<i>11.07</i>	<i>12.59</i>	
Dire Dawa	<i>7.81</i>	<i>11.07</i>	<i>12.59</i>	<i>12.59</i>	<i>16.92</i>	<i>16.92</i>	<i>15.51</i>	
Gelemso	<i>5.99</i>	<i>5.99</i>	<i>7.81</i>	<i>7.81</i>	<i>9.49</i>	<i>7.81</i>	<i>7.81</i>	
Haramaya	<i>9.49</i>	<i>11.07</i>	<i>12.59</i>	<i>12.59</i>	<i>12.59</i>	<i>11.07</i>	<i>12.59</i>	
Harar	<i>5.99</i>	<i>9.49</i>	<i>9.49</i>	<i>9.49</i>	<i>11.07</i>	<i>9.49</i>	<i>7.81</i>	
Miesso	<i>11.07</i>	<i>12.59</i>	<i>12.59</i>	<i>11.07</i>	<i>12.59</i>	<i>12.59</i>	<i>12.59</i>	

4.2. Optimized IDF Curve Coefficients

Table 4.3. Summary of IDF parameters for selected return periods

No	Name of Station	2-years			5-years			10-years		
		a	b	c	a	b	c	a	b	c
1	Dengego	69.91	56.92	0.5945	161.87	30.18	0.6749	225.93	27.42	0.6981
2	Dire Dawa	7.65	0.01	0.2173	77.00	123.37	0.4952	199.72	183.68	0.5978
3	Gelemso	117.59	25.80	0.5811	229.08	33.49	0.6199	315.25	35.47	0.6301
4	Haramaya	33.09	0.017	0.3860	185.51	0.056	0.5909	281.46	0.202	0.6314
5	Harar	6.78	0.10	0.1692	85.53	0.02	0.5042	274.16	0.02	0.6560
6	Miesso	11.10	0.12	0.254	756.39	440.90	0.7691	879.38	347.80	0.7736

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Table 4.4. Summary of IDF parameters for selected return periods

No	Name of Station	25-years			50-years			100-years		
		a	b	c	a	b	c	a	b	c
1	Dengego	286.01	27.42	0.6981	314.92	29.18	0.6969	359.15	36.89	0.6966
2	Dire Dawa	229.17	175.15	0.5838	237.10	197.37	0.5625	245.36	208.44	0.5515
3	Gelemso	408.26	32.27	0.6244	461.69	27.42	0.6118	503.33	21.57	0.5951
4	Haramaya	340.91	0.467	0.6402	345.47	0.048	0.6310	337.51	0.069	0.6184
5	Harar	848.74	0.01	0.8016	1660.83	0.02	0.8869	2920.93	0.00	0.9579
6	Miesso	883.89	246.51	0.7618	932.09	197.30	0.7621	981.42	157.88	0.7640

4.3. Parameter Testing

Table 4.5. Values of coefficient of determination (r^2)

Stations	Return Periods					
	2	5	10	25	50	100
Dengego	0.9864	0.9938	0.9951	0.9901	0.9798	0.9616
Dire Dawa	0.8127	0.8946	0.9545	0.7812	0.6500	0.5597
Gelemso	0.9872	0.9848	0.9776	0.9621	0.9464	0.9279
Haramaya	0.8985	0.9813	0.9879	0.9835	0.9760	0.9665
Harar	0.7868	0.9814	0.9761	0.9586	0.9435	0.9295
Miesso	0.6206	0.7666	0.9252	0.9553	0.9948	0.9790

Table 4.6. Values of coefficient of correlation (r)

Stations	Return Periods					
	2	5	10	25	50	100
Dengego	0.9932	0.9970	0.9976	0.9950	0.9900	0.9806
Dire Dawa	0.9015	0.9459	0.9770	0.8839	0.8062	0.7481
Gelemso	0.9936	0.9924	0.9890	0.9809	0.9729	0.9633
Haramaya	0.9480	0.9906	0.9939	0.9917	0.9880	0.9831
Harar	0.8870	0.9906	0.9880	0.9791	0.9714	0.9641
Miesso	0.7878	0.8756	0.9619	0.9977	0.9974	0.9894

4.4. Construction of Intensity-Duration-Frequency Curves

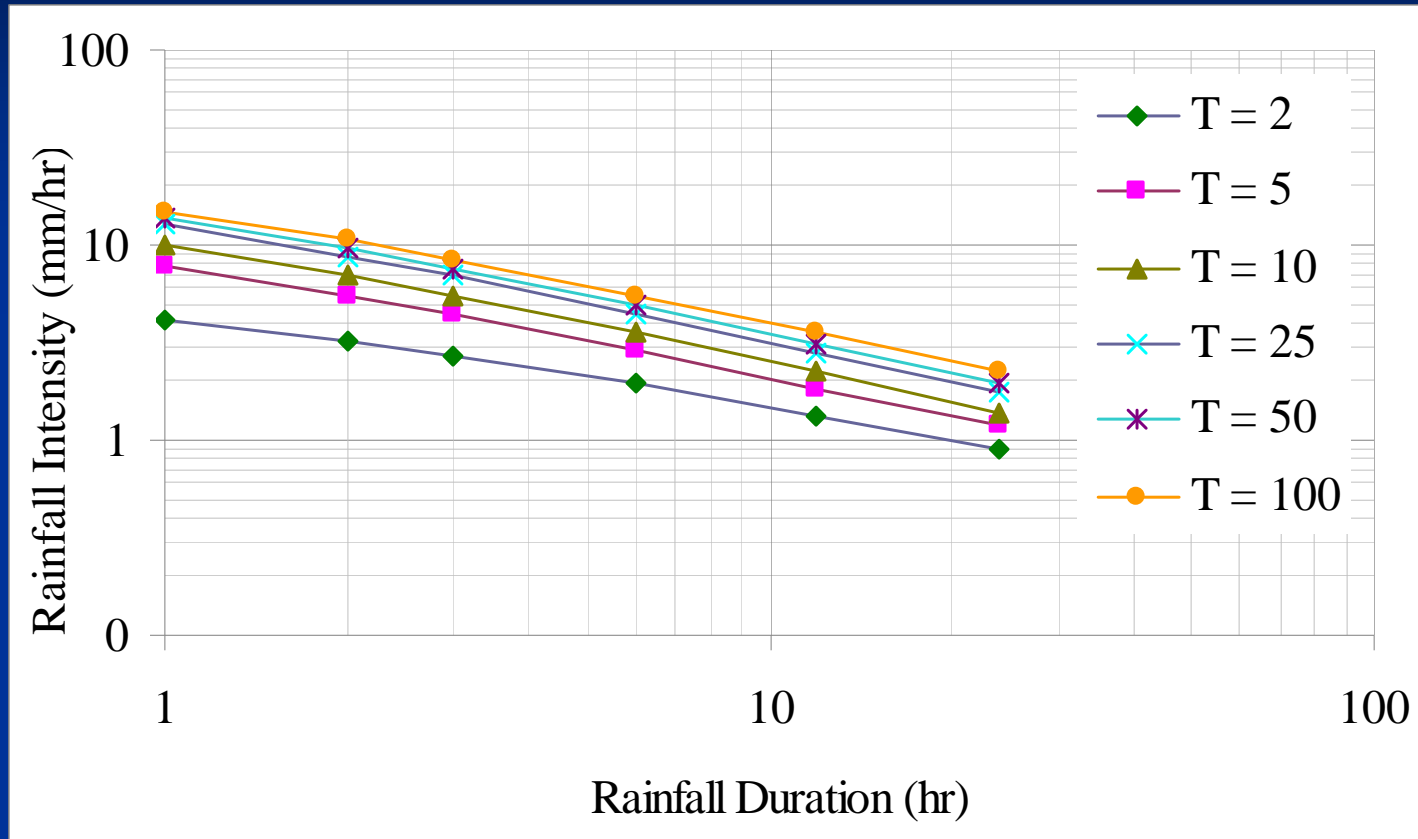


Figure 4.1. IDF curves for Dengego station

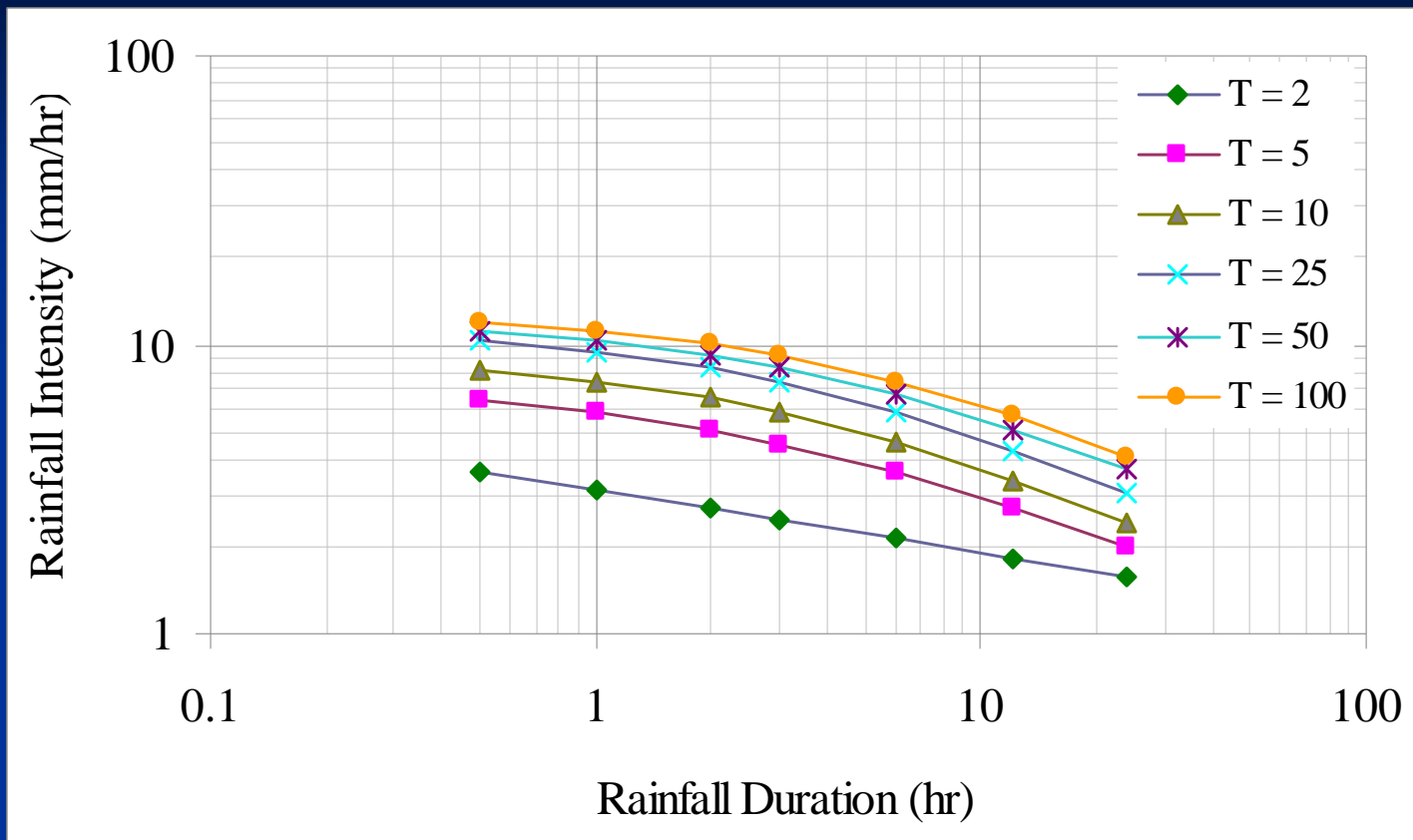


Figure 4.2. IDF curves for Dire Dawa station

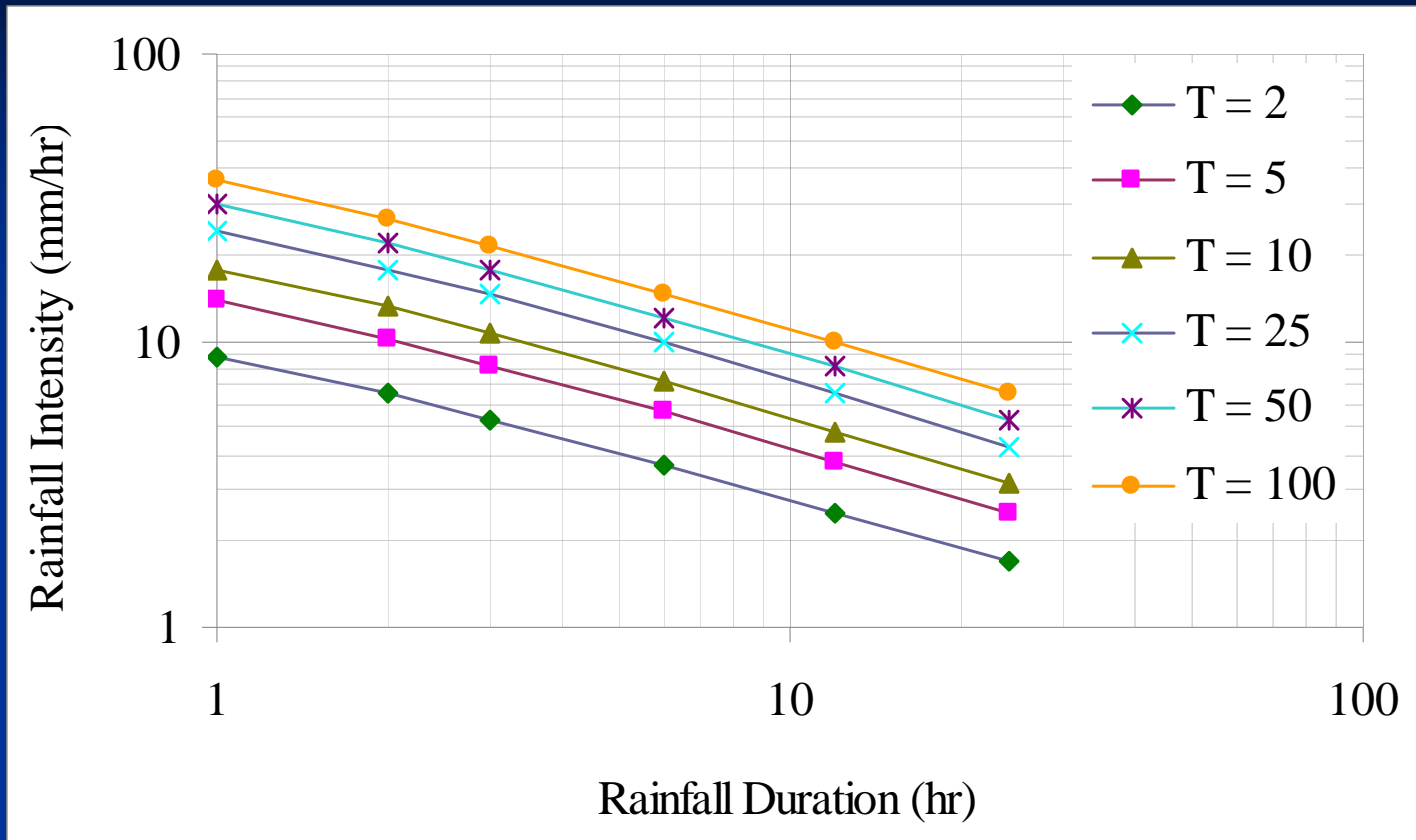


Figure 4.3. IDF curves for Gelemso station

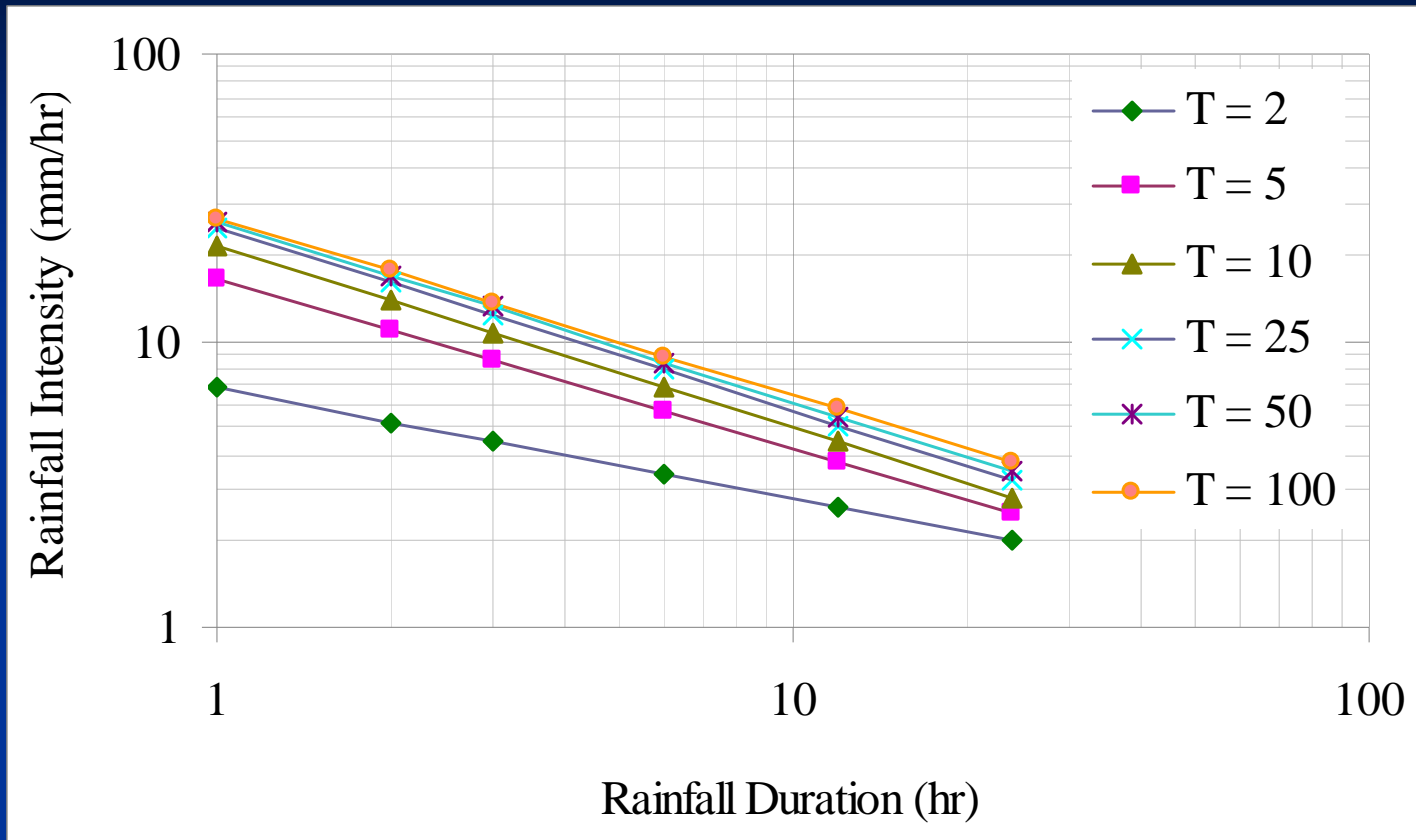


Figure 4.4. IDF curves for Haramaya station

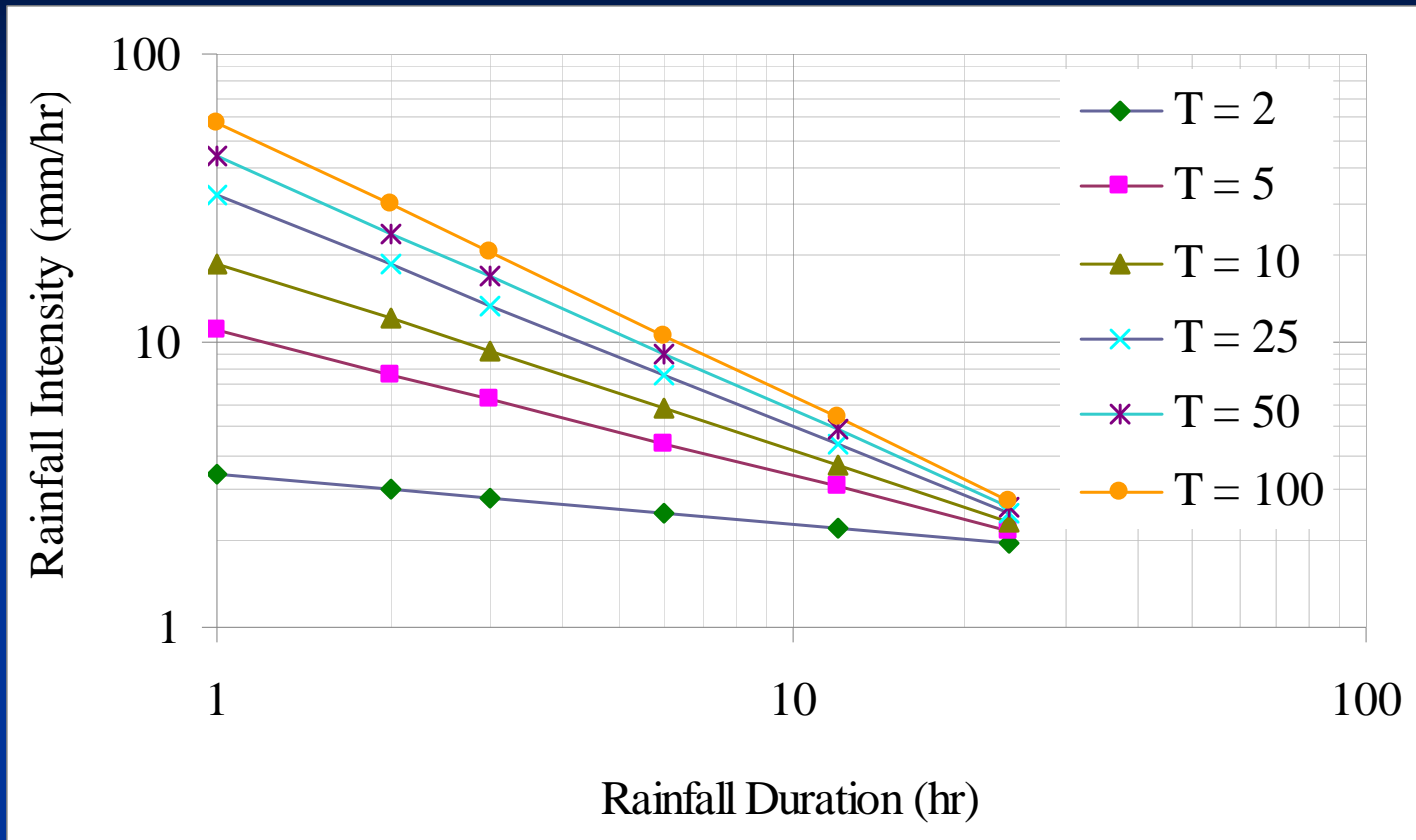


Figure 4.5. IDF curves for Harar station

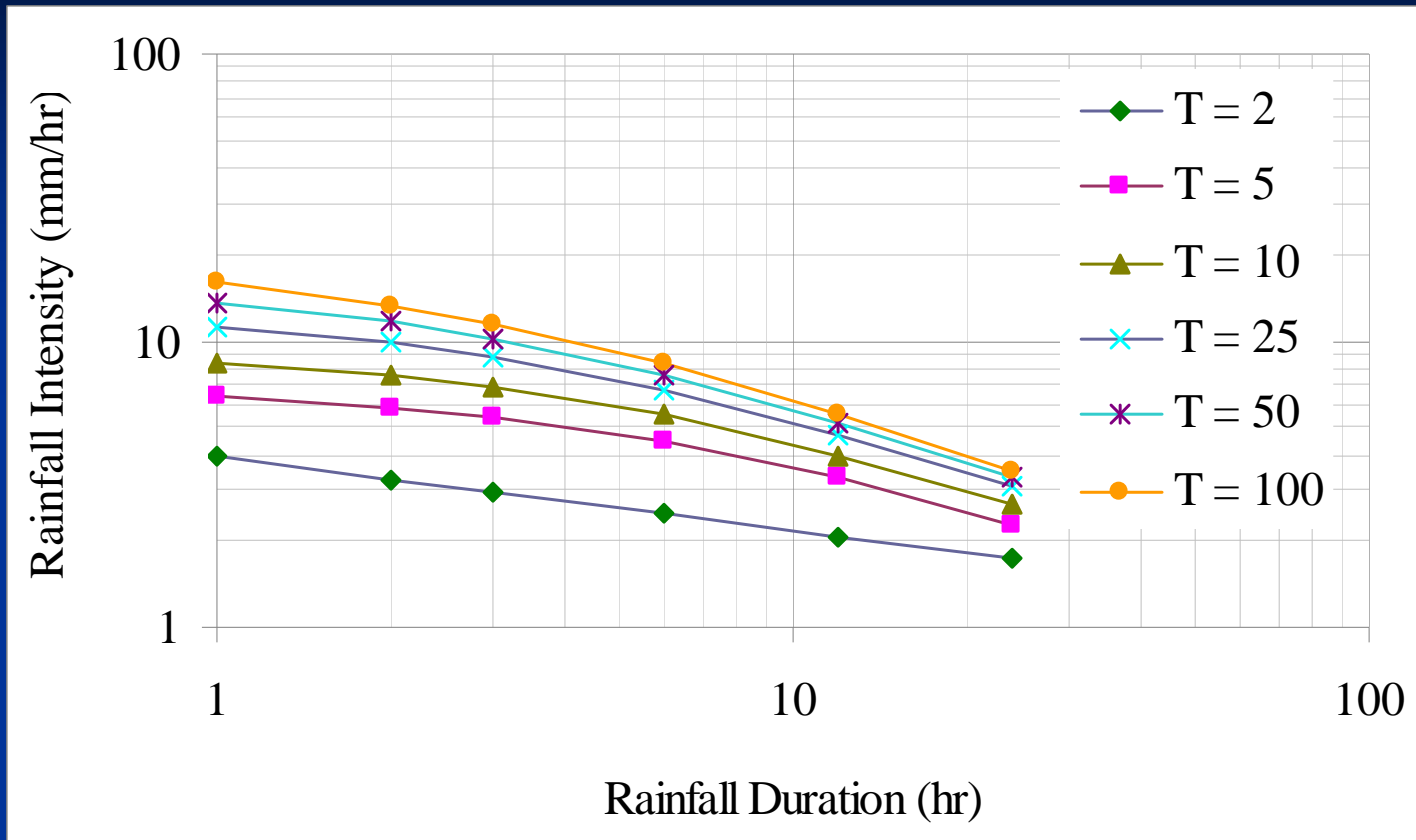


Figure 4.6. IDF curves for Miesso station

5. SUMMARY

- 🔔 The results obtained should serve to meet the need for rainfall Intensity-Duration-Frequency relationships for the study area.
- 🔔 The results of this study can be used to determine intensity or depth of rainfall within a radius of about 25 km² area of the respective stations.
- 🔔 It is hoped that, as more years of rainfall data are available, the existing Intensity-Duration-Frequency relationship curves need to be updated.
- 🔔 Correlation for IDF curves obtained from recording raingauge stations with that of non-recording raingauge stations needs to be developed to generate curves for the entire study area.

THANK YOU