**Establishment of rainfall Intensity-Duration-Frequency Equations and Curves used to design an appropriate and sustainable hydraulic structure for controlling flood in Nyabugogo catchment-Rwanda.**

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**Supplementary Information**

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**SUPPLEMENTARY INFORMATION**

**Table 1.** Daily AMS Analysis with its Sample and distribution parameters for Gitega Meteorological station.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Year** | **X(Observed)** | **Rank** | **p** | **u** | **X(Gumb)** |
| 1998 | 144 | 1 | 0.015086207 | 4.186383451 | 157.0447707 |
| 2005 | 134 | 2 | 0.042025862 | 3.148079644 | 131.8616376 |
| 2001 | 119 | 3 | 0.068965517 | 2.638631924 | 119.5054374 |
| 2006 | 113 | 4 | 0.095905172 | 2.294408351 | 111.1566015 |
| 1996 | 98 | 5 | 0.122844828 | 2.03201332 | 104.792444 |
| 2003 | 95 | 6 | 0.149784483 | 1.818521939 | 99.61440094 |
| 1982 | 93 | 7 | 0.176724138 | 1.637508513 | 95.22408168 |
| 1981 | 87 | 8 | 0.203663793 | 1.479577824 | 91.39361363 |
| 2004 | 83 | 9 | 0.230603448 | 1.33884311 | 87.98021863 |
| 1999 | 80 | 10 | 0.257543103 | 1.211365188 | 84.88835529 |
| 1983 | 76 | 11 | 0.284482759 | 1.094372539 | 82.0508029 |
| 2007 | 76 | 12 | 0.311422414 | 0.985835689 | 79.41833837 |
| 1984 | 73 | 13 | 0.338362069 | 0.884218575 | 76.95370587 |
| 1987 | 73 | 14 | 0.365301724 | 0.788325161 | 74.62789662 |
| 1988 | 71 | 15 | 0.392241379 | 0.697200421 | 72.41774731 |
| 2013 | 71 | 16 | 0.419181034 | 0.610063878 | 70.30432815 |
| 2010 | 67 | 17 | 0.44612069 | 0.526263396 | 68.27182218 |
| 1995 | 64 | 18 | 0.473060345 | 0.445241956 | 66.30671939 |
| 2015 | 64 | 19 | 0.5 | 0.366512921 | 64.39721683 |
| 1997 | 61 | 20 | 0.526939655 | 0.289640897 | 62.53275443 |
| 2002 | 60 | 21 | 0.55387931 | 0.21422623 | 60.70363894 |
| 1993 | 59 | 22 | 0.580818966 | 0.139891703 | 58.90072126 |
| 2000 | 57 | 23 | 0.607758621 | 0.066270297 | 57.11509969 |
| 2009 | 57 | 24 | 0.634698276 | -0.007007019 | 55.33782373 |
| 1992 | 54 | 25 | 0.661637931 | -0.080324588 | 53.55957146 |
| 1990 | 51 | 26 | 0.688577586 | -0.15409786 | 51.77026654 |
| 2012 | 50 | 27 | 0.715517241 | -0.228793663 | 49.95858642 |
| 1989 | 49 | 28 | 0.742456897 | -0.304958114 | 48.11128557 |
| 1994 | 49 | 29 | 0.769396552 | -0.383257479 | 46.21220429 |
| 2014 | 49 | 30 | 0.796336207 | -0.464541689 | 44.24072826 |
| 2016 | 48 | 31 | 0.823275862 | -0.549949393 | 42.16924055 |
| 1988 | 45 | 32 | 0.850215517 | -0.641094545 | 39.95859614 |
| 2011 | 41 | 33 | 0.877155172 | -0.740428247 | 37.54934578 |
| 1991 | 37 | 34 | 0.904094828 | -0.852027528 | 34.84260472 |
| 2008 | 37 | 35 | 0.931034483 | -0.983631068 | 31.6506782 |
| 1986 | 34 | 36 | 0.957974138 | -1.153564409 | 27.52909653 |
| 2017 | 21 | 37 | 0.984913793 | -1.433648829 | 20.73589864 |
| Sample Mean µs | 68.64864865 |  |  |  |  |
| Sample st.Dev σs | 27.5017335 |  |  |  |  |
| Position parameter **(x0)** | 55.50777273 |  |  |  |  |
| Scale parameter **(s**) | 24.25410838 |  |  |  |  |
| Gumbel Mean **(µG)** | 69.50724409 |  |  |  |  |
| Gumbel st.Dev σG | 31.105894 |  |  |  |  |

With **p**: Exceedance probability, **u**: Reduced variable, and **XG**: Gumbel variable .

**Text 1** In the second column of Table S1; sampled extreme rainfall depth, in mm, is ordered in descendent order. In column four values are exceedance probabilities obtained with Gringorten formula. The reduced valuable u is computed using expression (Eq.3.2; Main manuscript). In the last column are given the expected values as were directed by generated by Gumbel distribution in accordance with formula (Eq.3.7; Main manuscript). The mean and standard deviation of the sample and the parameters of the distribution are computed as have seen in the above table.

**Table 2.** Rainfall IDF empirical equation for respective return period and their correlation coefficient, R for Gasabo District.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Return**  **Period( Year)** | **x** | **y** | **Equation** | **Correlation**  **Coefficient (R)** |
| 2 | 403.81 | 0.67 | I=403.81 (td)-0.67 | R=1 |
| 5 | 506.67 | 0.67 | I=506.67 (td)-0.67 | R=1 |
| 10 | 575.12 | 0.67 | I=575.12 (td)-0.67 | R=1 |
| 25 | 661.55 | 0.67 | I=661.55 (td)-0.67 | R=1 |
| 50 | 758.59 | 0.67 | I= 758.59(td)-0.67 | R=1 |
| 100 | 789.54 | 0.67 | I=789.54 (td)-0.67 | R=1 |

**Table 3.** Rainfall IDF empirical equation for respective return period and their correlation coefficient, R for Rulindo District.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Return**  **Period( Year)** | **x** | **y** | **Equation** | **Correlation**  **Coefficient (R)** |
| 2 | 328.33 | 0.67 | I=328.33 (td)-0.67 | R=1 |
| 5 | 457.5 | 0.67 | I=457.5 (td)-0.67 | R=1 |
| 10 | 543.23 | 0.67 | I=543.23 (td)-0.67 | R=1 |
| 25 | 651.33 | 0.67 | I=651.33 (td)-0.67 | R=1 |
| 50 | 731.5 | 0.67 | I=731.5 (td)-0.67 | R=1 |
| 100 | 811.22 | 0.67 | I=811.22 (td)-0.67 | R=1 |

**Table 4.** Rainfall IDF empirical equation for respective return period and their correlation coefficient, R for Gatsibo District.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Return**  **Period( Year)** | **x** | **y** | **Equation** | **Correlation**  **Coefficient (R)** |
| 2 | 304.95 | 0.67 | I=304.95 (td)-0.67 | R=1 |
| 5 | 413.73 | 0.67 | I=413.73 (td)-0.67 | R=1 |
| 10 | 485.92 | 0.67 | I= 485.92(td)-0.67 | R=1 |
| 25 | 576.96 | 0.67 | I=576.96 (td)-0.67 | R=1 |
| 50 | 644.47 | 0.67 | I=644.47 (td)-0.67 | R=1 |
| 100 | 711.6 | 0.67 | I=711.6 (td)-0.67 | R=1 |

**Table 5.** Rainfall IDF empirical equation for respective return period and their correlation coefficient, R for Kayonza District.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Return**  **Period( Year)** | **x** | **y** | **Equation** | **Correlation**  **Coefficient (R)** |
| 2 | 337.43 | 0.67 | I=337.43 (td)-0.67 | R=1 |
| 5 | 478.25 | 0.67 | I=478.25 (td)-0.67 | R=1 |
| 10 | 571.7 | 0.67 | I=571.7 (td)-0.67 | R=1 |
| 25 | 687.55 | 0.67 | I=687.55 (td)-0.67 | R=1 |
| 50 | 776.94 | 0.67 | I=776.94 (td)-0.67 | R=1 |
| 100 | 863.86 | 0.67 | I=863.86 (td)-0.67 | R=1 |

**Table 6.** Frequency Factors for Rational Formula and its Recurrence Interval (years).

|  |  |
| --- | --- |
| **Recurrence Interval (years)** | **Frequency factor (Cf)** |
| 10 or less | 1.0 |
| 25 | 1.1 |
| 50 | 1.2 |
| 100 | 1.25 |

**Text 2** All these Rainfall IDF empirical equations for respective return period and their correlation coefficient tables, from the table, S2 up to table S5, their IDF Curve’s figures are in the main manuscript (Figure 4a to 4d): Rainfall IDF curve for **(a)** Kabuye sugar station-Gasabo District, **(b)** Rulindo station-Rulindo District, **(c)** Kiziguro station-Gatsibo District and **(d)** Kayonza station-Kayonza District*.*