**Prospective sites for Ice-tower constructions GIS terrain and proximity data:**

|  |  |
| --- | --- |
| *E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04456.JPG*  N | E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04454.JPG  N |
| *Phaterak\_lower:Inlet* | Phaterak\_lower: Outlet |
| *E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04517.JPG*  N | E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\FDC\photo1_fdc_TriBhuvan_FdcBhuvanTGW_LinearPlantation_Line_cf5d0af3a08b907_13_7_15_16_10_2019.jpg  N |
| *Phaterak\_higher:Inlet* | Phaterak\_higher:Outlet |
| *E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\FDC\photo1_fdc_TriBhuvan_FdcBhuvanTGW_LinearPlantation_Line_cf5d0af3a08b907_8_6_2_19_10_2019.jpg* | E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04670.JPG |
| *Phuktsey:inlet* | Phuktsey:outlet (icetower active) |

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| *E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04409.JPG* | E:\IceStupa_Study\Sitevisit-Oct2019\Photos_Sitevisit\DSC04413.JPG |
| *Gangles upper icetower inlet and outlet* | Gangles lower icetower inlet and outlet |

*Fig 1: Icetower sites visited as part of Site visit to Phaterak, Gangles and Phuktsey in October 2019*

**Satellite data and products:**

- LISS-IV (5.4m MX) and Sentinel 2A/2B (20m MX) : Water stream polyline dilineation

- ALOS World 3D DEM (30 m posting) : Water stream polyline dilineation , Slope raster

**GIS tool:**

-> **Vector data**: Point data

i)Water stream, ii)Slope suitable sites

-> **Criteria:**

i) inlet to outlet elevation difference > 60m

ii) Inlet-Outlet Distance < 500m

-> **Output:**

- Optimal inlet satisfy: Set of (Outlet\_optimal, Inlet\_optimal)

--Slope Suitable locations: Slope <= 14 deg

- Minimum possible distance for Inlet - Outlet pair, ensuring the criteria are satisfied

i) Outlet\_optimal := {Outlet: dist = min{dist(Inlet, SlopeSuitable)}}

ii) Inlet\_optimal = { Inlet\_outletsuitable : dist = min{dist(Outlet\_optimal, Inlet[Outlet\_optimal])}}

**Phaterak(Phyang):**

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| E:\IceStupa_Study\QGIS_tool\result_analyze\Phaterak_locn_optimallocn_existinglocn.JPG |
| Phaterak\_lower: Existing inlet-outlet (Vs) Optimal location comparision |
| E:\IceStupa_Study\QGIS_tool\result_analyze\Phaterak_locn_pipelength_straightpath_Zcomparision.JPG |
| Phaterak\_lower: Existing inlet-outlet (Vs) Calculated inlet-outlet comparision |

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| Location\_Phaterak lower | Head(m) (DEM) | Horizontal Distance component(m) | Distance(m) | Head/Distance |
| Existing | 42 | 144 | 150 | 0.28 |
| Closest Icetower\_Distance\_optimized | 60 | 307 | 312.808248 | 0.191810799 |

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| E:\IceStupa_Study\QGIS_tool\result_analyze\PhaterakTop_locn_optimallocn_existinglocn.JPG |
| Phaterak\_upper: Existing inlet-outlet (Vs) calculated optimal inlet outlet locations |
| E:\IceStupa_Study\QGIS_tool\result_analyze\PhaterakTop_locn_pipelength_Zcomparision.JPG |
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| --- | --- | --- | --- | --- |
| Location\_Phaterak\_upper | Head(m) (DEM) | Horizontal Distance component(m) | Distance(m) | Head/Distance |
| Existing | 57 | 423 | 426.8231 | 0.133545 |
| Closest Icetower\_Distance\_optimized | 63 | 357 | 362.5162 | 0.173785 |

**Gangles(Leh):**

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| Gangles Upper |
| E:\IceStupa_Study\QGIS_tool\result_analyze\gangles_lower_locn_pipelength_straightpath_Zcomparision.JPG |
| Gangles Lower |

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| --- | --- | --- | --- | --- |
| Location\_Gangles\_upper | Head(m)(DEM) | Horizontal Distance component(m) | Distance(m) | Head/Distance |
| Existing | 57 | 184 | 192.6266 | 0.295909 |
| Closest Icetower\_Distance\_optimized | 72.65 | 176 | 190.4049 | 0.381555 |

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| --- | --- | --- | --- | --- |
| Location\_Gangles | Head(m) (DEM) | Horizontal Distance component(m) | Distance(m) | Head/Distance |
| Existing | 67 | 269 | 277.2183 | 0.249071 |
| Closest Icetower\_Distance\_optimized | 81 | 211 | 226.0133 | 0.383886 |

**Phuktsey(Shara):**

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| Phuktsey: Existing inlet-outlet (Vs) Optimal location comparison |
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| Phuktsey: Existing inlet-outlet and nearest optimal icetower-pipeline |

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| --- | --- | --- | --- | --- |
| Location\_Phuktsey | Head(m) (DEM) | Horizontal Distance component(m) | Distance(m) | Head/Distance |
| Existing | 51 | 374 | 378 | 0.135113 |
| Closest Icetower\_Distance\_optimized | 60 | 433.5 | 437.6326 | 0.137101 |

Drawbacks with existing dataset:

i) DEM: Currently ASW3D with 30m posting. Accuracy:??(Check)

-To get precise head difference values, so that the inlet and outlet identified will be precise to within 5m vertical error

-To detect regions with area less than 60mx60m, with suitable slope.

-Noticed DEM elevation difference(head\_dem) is less than the on-site head difference(head\_onsite)

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| --- | --- | --- | --- |
| Location | Head\_dem | Head\_onsite | Reason |
| Gangles\_stream to icetower | 36.3 | 63 | Location mismatch(inaccurate location) & high slope |
| Phaterak | 36.26 | 41 | -same as above- |
| Phuktsey | 49.7225 | 51 | Low slope => less elevation variation |
|  |  |  |  |

ii) Accurate Water stream layer (need Bhuvan Suvidha)

-To get positionally accurate dilineation of water stream, so that the suitable inlet and outlets

-Need to ensure the features and DEM are positionally registered

Improvements for future work:

-> Accurate inlet-outlet distance: Use least cost path calculation for pipeline path.

-> Evaluate the alternative criteria (eg: head, head/distance ratio, Optimality grading) for identifying the optimal outlet and inlet, to give better decision making onsite.

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| Phuktsey(Shara) optimal icetower locations identified among the slope suitable locations |

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|  |
| Phaterak(Phyang) optimal icetower locations identified among the slope suitable locations |

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| E:\IceStupa_Study\QGIS_tool\result_analyze\Gangles_optimalicestupas_overview.JPG |
| Gangles(Leh) optimal icetower locations identified among the slope suitable locations |