Appendix J– Results for the Irrigation Storage Dam Decision Support Model

This Section outlines the rating results for 159 storage projects. Ratings are based on a decision support model with the nine criteria defined below. Each has a rating scale. Some are standard (higher values give higher ratings), and some are reversed (higher values give lower ratings). The values for the criteria are normalized (rescaled to a value between 0 and 1), weighted by importance in the model, and summed. The sum is a final rating for the project.

Figure 1 shows the decision support model with attached weights for each criterion. Each criterion and the rating system for it are described in detail below. These sub-ratings all range from zero to one in the decision support model.

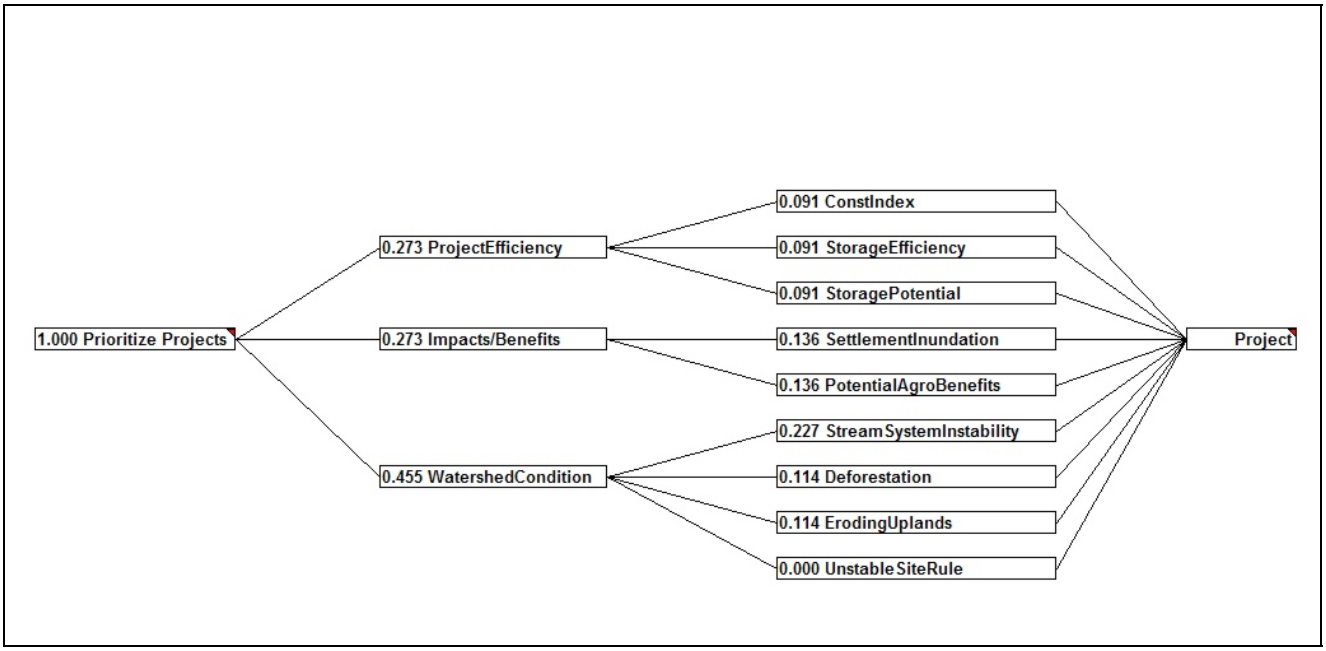

Figure 1. Storage Decision Model Hierarchy with Weights

ConstIndex (Construction Index): This is a rating of dam construction cost, based on construction volume. Higher construction volume is correlated linearly to increased cost of construction. This is an inverse scale with higher ratings for lower cost. Rating endpoints come from the range of available data.

StoragePotential: Storage potential relates to the water balance for the project. It is rated on irrigation service area based on a standardized agricultural system demand (winter wheat) and a water balance model for the project dam and associated watershed. The service area was increased until the reservoir ran dry in June. This provides a rating of potential season-long irrigation water. Larger service areas are given higher ratings. Rating endpoints come from the range of available data.

StorageEfficiency: Storage efficiency is related to the available potential storage compared to the size of the dam. Higher ratings indicate a higher volume of storage for a given size of dam, or higher efficiency. This is a ratio, calculated from potential storage volume over total construction volume. Higher values give higher ratings. Rating endpoints come from the range of available data.

SettlementInundation: This is a measure of the potential negative impact of any projects on local populations. It estimates inundation of dwellings and bridges. A higher total inundated dwelling and bridge quantity is rated as a higher impact. Therefore this is a reversed scale, with higher numbers resulting in a lower rating. Rating endpoints come from the range of available data.

PotentialAgroBenefits: This rating indicates the degree to which there is infrastructure to support increased agricultural operations, and is also used to estimate potential affected population. It is rated by the area of presently-irrigated land less than 9 km downstream from the project. The 9 km limit was estimated as the largest distance practical over which benefits could be developed. A higher area of irrigated land indicates a higher benefit. Rating endpoints come from the range of available data.

Deforestation: Deforestation affects watersheds by increasing sedimentation and peak flows, which reduces water quality and downstream benefits. The proportion of deforestation was measured using LANDSAT imagery and a vegetation change model using the last 10 years as a base. The scale is inverse with higher values resulting in lower ratings. Rating endpoints come from the range of available data.

StreamSystemInstability: This rating reflects the instability of stream systems, which influences sediment and flooding. It is a reversed scale, with lower values resulting in higher ratings. Since this rating is the most critical for influencing reservoir life, dam design, and maintenance needs it is weighted twice as heavily as the other watershed factors (Figure 1). Rating endpoints come from the range of available data.

ErodingUplands: Eroding lands are those uplands that have active gully and rill erosion. Their presence is related to relatively erodible soils, slope, climate, and poor land use practices. A higher proportion of eroding lands indicates lower land productivity and water quality. The scale is therefore reversed, with higher values giving lower ratings. Rating endpoints come from the range of available data.

UnstableSiteRule: Though having unstable stream systems anywhere in the watershed may increase costs and influence the design of a project, the presence of a large, unstable stream system at or near the project site may critically influence the construction and maintenance of a dam. This case is captured by a criterion-based rule. This flags the rating, recognizing the importance of this criterion, *but does not affect the rating of the project*.

Criteria and group weights were initially set to an equal weighting. In other words, *project efficiency*, *watershed condition* and *benefits/impacts* were all given equal importance, as were each criterion in each group. However, based on feedback from clients watershed condition was seen to be more important in long-term project success, so was weighted more heavily in the model. Both the Watershed Condition group and the Stream System Instability criterion were weighted twice as heavily as others, resulting in the final weights in Figure 1 and in Table 1 below.

Each Rating Criterion is described in Table 1. The Data Field Name is the dBase-compatible field used in acquiring data values which are then normalized from the range of data, e.g. the High Limit is used for either a Data Field Name value of 1 or 0, depending on the scale (standard or reversed). Ranges of data come from data from all 159 storage dam projects (Table 7 and 8 in Appendix O).

Table 1. Storage Dam Decision Support Model Rating Specifications

Rating Criterion	Data Field Name	Weights	Units	Low Limit	High Limit	Range	Scale
ConstIndex (Dam volume)	CNSTINDV	0.091	m3	1084	2,783,616.0	2,782,532.0	reverse
StorageEfficiency	STRGEFFC	0.091	ratio of storage volume to cost volume	0.2	836.0	835.8	standard
StoragePotential	STRGPOTL	0.091	Ha	0	24,506.0	24,506.0	standard
SettlementInundation	STTLINUN	0.136	# Dwellings+bridges	0	1,187.0	1,187.0	reverse
PotentialAgroBenefits	POTAGBNF	0.136	Ha	0	913.4	913.4	standard
StreamSystemInstability	UNSTSTRS	0.227	% of watershed	0	100.0	100.0	reverse
Deforestation	DEFORESTN	0.114	% of watershed	0	11.7	11.7	reverse
ErodingUplands	ERODNGLN	0.114	weighted % of watershed	19.4	42.9	23.5	reverse
UnstableSiteRule	SITEUNST	0	no/yes	0	1.0	1.0	standard

Of the total 295 proposed water resource projects, 159 irrigation storage project sites have been located throughout the Study Area. Figure 2 shows these projects. Project location is symbolized by green dots. Strong brown polygons outline study sub-basins, and faint brown lines show province boundaries.

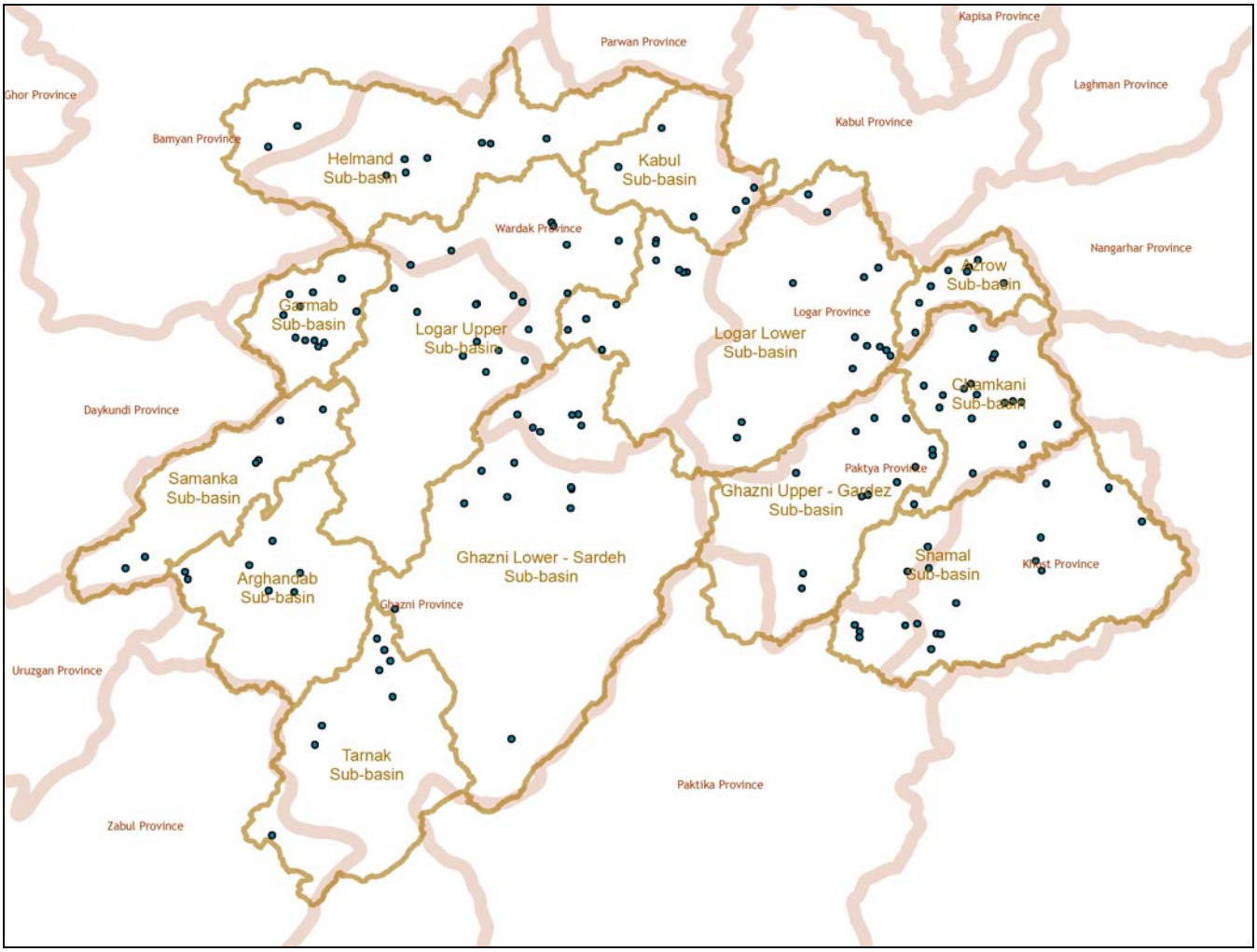

Figure 2. Storage project locations

Tables 7 and 8 in Appendix O include data for all dam heights (159 projects x 4 dam heights for 636 total). They contain project name, the ratings ("Results"), and all the criterion values. For each criterion, the first name is the decision support model name (e. g. StreamSystemInstability), and contains the normalized rating (before weighting), and the succeeding Dbase compatible name contains the raw data score (e.g. UNSTRSRS). Heights of the maximum potential dam (Max) are contained in Table 11, Appendix O. The first value in each pair is weighted and summed with the other eight to form the total rating score. Project descriptions in terms of construction parameters are given in Section 6.2 in the main document.

Ratings of these projects are all relative. That is, the system rates from "best" to "worst". Absolute factors may also influence whether any of these projects are feasible, or "good" or "bad". One of these is the presence of large, unstable stream channels on the project site. This has been shown to be a very poor situation for maintenance and operation of any project. This is not used in the rating system. That is because it is not an inherently variable criterion (it is binary) and can be mitigated with design, so was left as informational only. The factor is modeled by the non-rated criterion "UnstableSiteRule" from the decision hierarchy in Figure 1 above. A site having this situation shows as "yes" in Table 8 in Appendix

O. This factor occurs in 51 of the total 159 projects. It is mapped in image Figure 3 as gray stars. Those same stars show up in all subsequent images underlying the rating symbol. Table 2 shows the names of projects with this site factor.

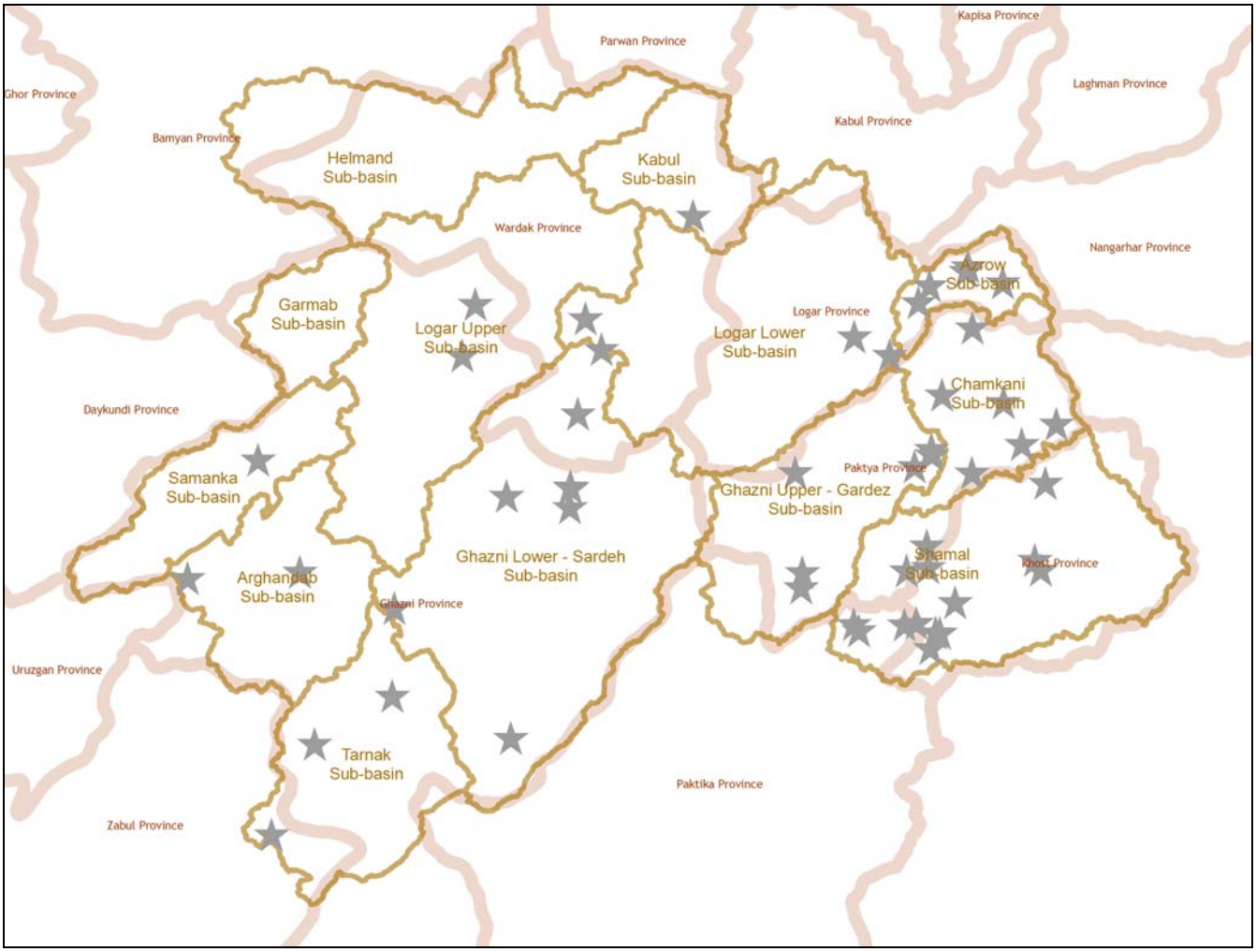

Figure 3. Unstable Site Locations for Irrigation Storage Dam Projects

Table 2. Project Locations with Unstable Sites

Name	UnstableSite	Name	Unstable Site
Acarkhel	yes	Mana	yes
Babar #1	yes	Meserkhel	yes
Bar Deray	yes	Nasirkhel	yes
Bazak	yes	Nawrak	yes
Dadikhel	yes	Nika #1	yes
Dar-e Akhshi	yes	Niw Qal'a #2	yes
Dehbakhshi	yes	Pala	yes
Dewkhana	yes	Qala-i Surkh #1	yes

Name	UnstableSite	Name	Unstable Site
Dokanha-i-Gomaran	yes	Qala-i Surkh #2	yes
Galgay	yes	Rabat	yes
Ganday Shykhan	yes	Sengasi	yes
Gardedkhwahi	yes	Shahbedak	yes
Ghorka Kalay	yes	Shali	yes
Ghorma	yes	Shekhan	yes
Ghorushtay	yes	Sorwakay	yes
Gurgkushta	yes	Sorway #1	yes
Kacwal	yes	Sulni Kalay #1	yes
Kala	yes	Sulni Kalay #2	yes
Khatinkhel	yes	Sultak	yes
Khushhalkhel	yes	Sur Gori	yes
Khushi	yes	Syahgel	yes
Koday	yes	Usmankhel #1	yes
Kosin #1	yes	Walan Rabat	yes
Kosin #2	yes	Wet	yes
Malistan	yes	Zambar	yes
		Zinak	yes

Four dam heights are rated for each project. Only the 12m dam is shown in most cases, because there is little difference between the overall rating scores for the other three dam heights (compare results between dam heights in Table 7 in Appendix O). This is generally due to the contribution of the higher-weighted watershed criteria which do not vary by dam height, and the potential agro-benefits (irrigated area downstream) which also does not vary by height.

Table 9 in Appendix O contains rating data, filtered for the 12m dam only (159 total). These ratings are symbolized in Figure 4 with higher ratings in shades of green. Site instability is shown in gray stars underlying the rating symbols. The NW part of the Study Area has most of the higher-rated projects, and has the fewest unstable sites as well. The sub-basin watersheds Shamal, Chamkani, and Ghazni Upper appear to concentrate the lowest ratings.

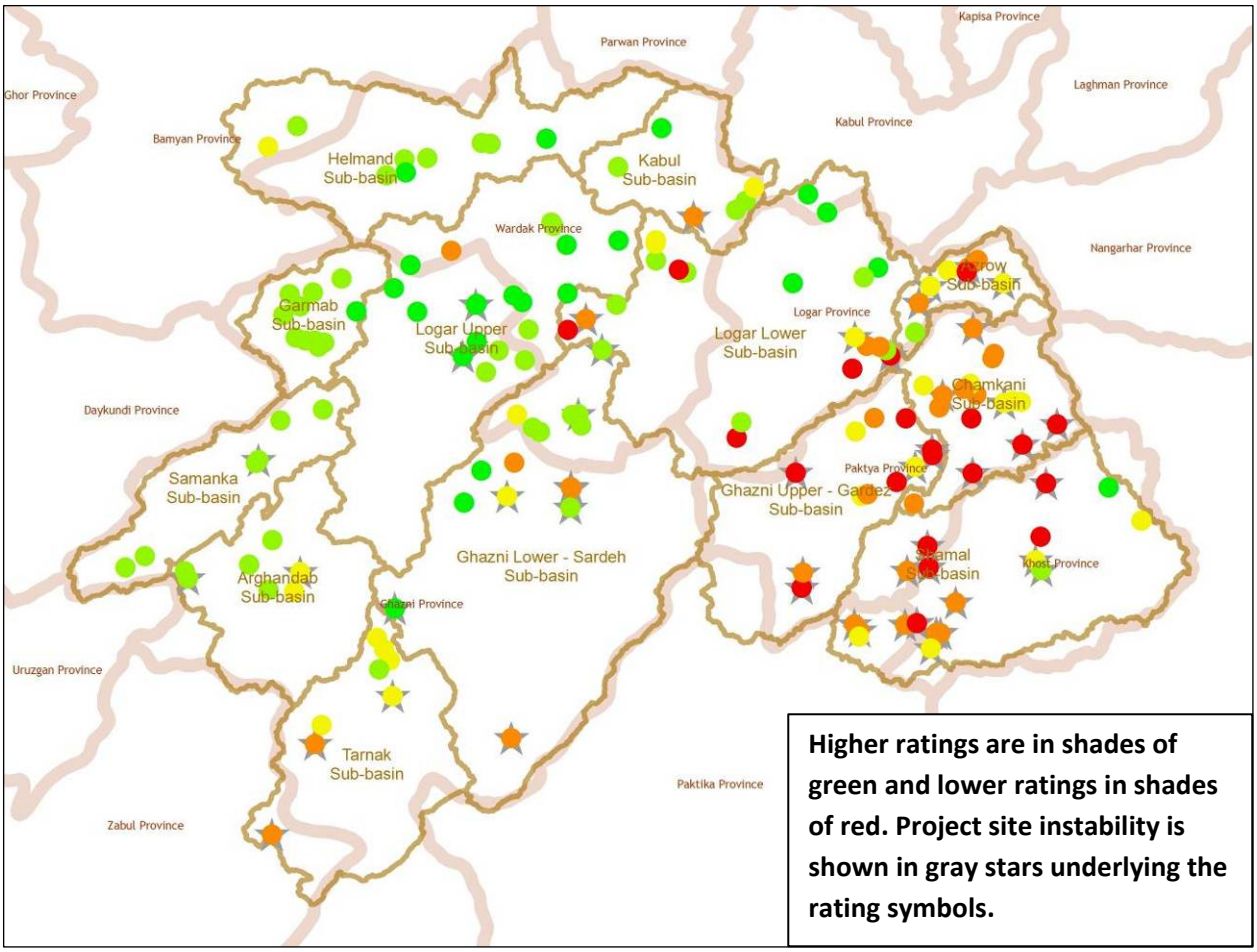

Figure 4. 12m Dam Irrigation Storage Dam Ratings

Table 3 shows just the top 20 rated projects for a 12 m dam. This is representative of all heights. This list is used to focus on the best potential projects. Figure 5 shows their location in the Study Area.

Table 3. Top 20 Irrigation Storage Dam Projects

Name	Province	Sub_Basin Watershed	UnstableSite	Height	Results	Partial Rating (Project side only)
Dehbakhshi	Ghazni	Ghazni Lower-Sardeh	yes	12	0.7805	0.238791
Kunj	Kabul	Logar Lower	no	12	0.768	0.458728
Shaghasi Kala	Logar	Logar Lower	no	12	0.745	0.447914
Niw Qal'a #2	Ghazni	Logar Upper	yes	12	0.7005	0.290762
Lashkari	Wardak	Logar Upper	no	12	0.698	0.292074
Ternawa	Ghazni	Logar Upper	no	12	0.679	0.275378
Baak #2	Khost	Shamal	no	12	0.6775	0.290791
Gadagak	Ghazni	Logar Upper	no	12	0.677	0.272799

Syahsangak	Ghazni	Ghazni Lower-Sardeh	no	12	0.6765	0.269312
Niw Qal'a #1	Ghazni	Logar Upper	no	12	0.676	0.263373
Kajab	Wardak	Logar Upper	no	12	0.675	0.275302
Namunyaz	Kabul	Logar Lower	no	12	0.6735	0.230809
Gurgkushta	Ghazni	Logar Upper	yes	12	0.673	0.263329
Bokan	Ghazni	Logar Upper	no	12	0.671	0.26756
Shew Qowl	Ghazni	Logar Upper	no	12	0.6705	0.2566
Sinak	Wardak	Helmand	no	12	0.668	0.281855
Chino Sar #1	Logar	Logar Lower	no	12	0.6645	0.240011
Bazari Sidaqat	Ghazni	Ghazni Lower-Sardeh	no	12	0.656	0.289506
Qal-eh-ye Shah	Wardak	Kabul	no	12	0.656	0.295859
Pitab Saydo	Wardak	Logar Upper	no	12	0.6555	0.271331

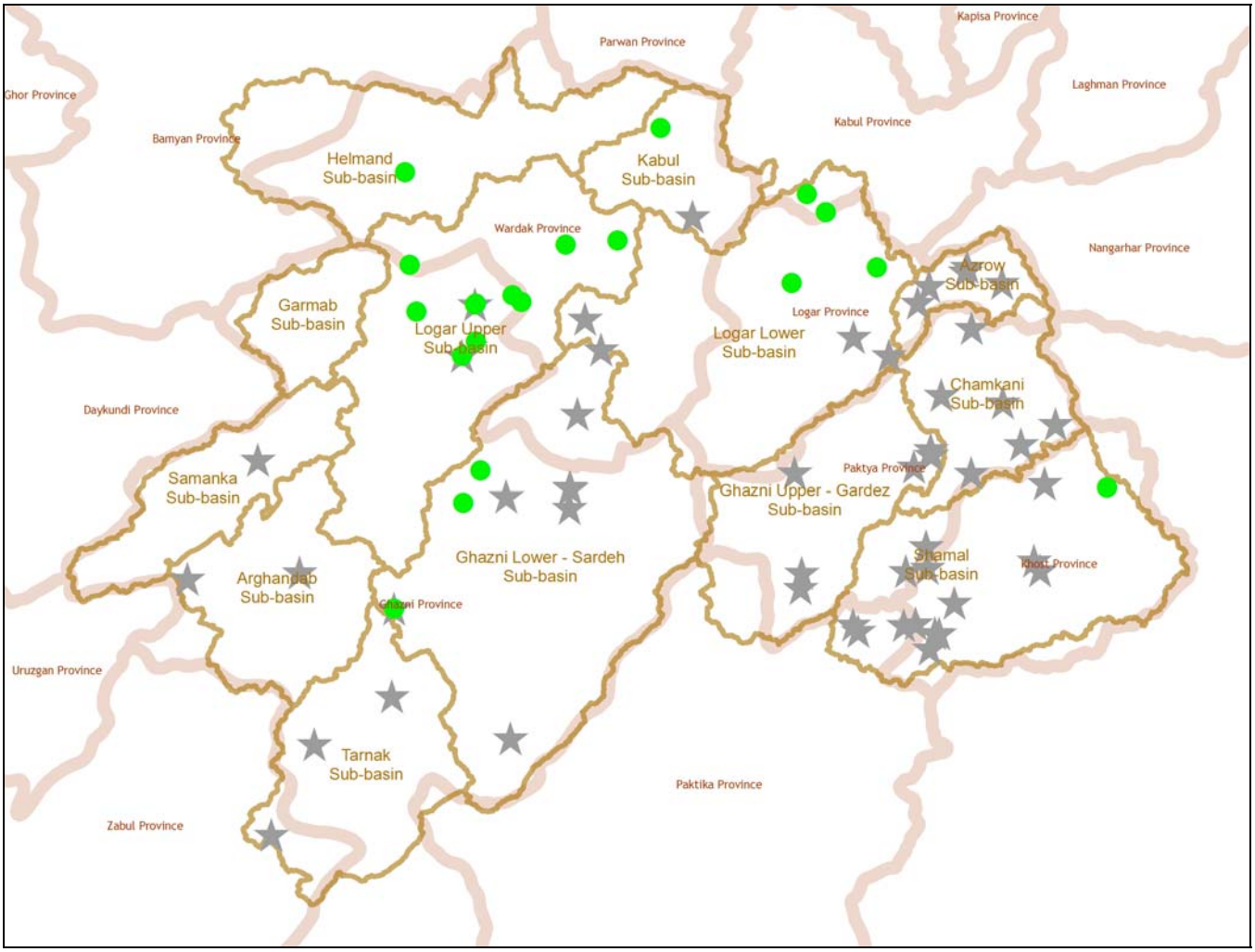

Figure 5. Top 20 Irrigation Storage Dam Projects (with gray stars indicating unstable sites).

Table 4 lists the 20 lowest-rated projects. Their location is shown in Figure 6. They are concentrated in the Shamal, Ghazni Upper and Chamkani Sub-basin watersheds.

Table 4. Bottom 20 Irrigation Storage Dam Projects

Name	Province	Sub_Basin Watershed	UnstableSite	Height	Results	Partial Rating (Project side only)
Zambar	Khost	Shamal	yes	12	0.35	0.249352
Sur Gori	Khost	Shamal	yes	12	0.356	0.237381
Sepahikhel	Paktya	Ghazni Upper-Gardez	no	12	0.356	0.238331
Zinak	Logar	Logar Lower	yes	12	0.367	0.231213
Madokhel	Paktya	Ghazni Upper-Gardez	no	12	0.386	0.258643
Nasirkhel	Paktya	Shamal	yes	12	0.389	0.237608
Shegaray	Paktya	Chamkani	no	12	0.389	0.238201
Kosin #2	Paktya	Ghazni Upper-Gardez	yes	12	0.391	0.276775
Kosin #1	Paktya	Ghazni Upper-Gardez	yes	12	0.392	0.277182
Abchakan	Logar	Logar Lower	no	12	0.395	0.230491
Gardedkhwahi	Paktya	Ghazni Upper-Gardez	yes	12	0.396	0.227364
Karakat	Wardak	Logar Lower	no	12	0.399	0.237287
Sultak	Paktya	Chamkani	yes	12	0.4	0.29695
Pala	Paktya	Chamkani	yes	12	0.403	0.263871
Shekhan	Paktya	Ghazni Upper-Gardez	yes	12	0.405	0.229487
Ghorma	Paktika	Shamal	yes	12	0.407	0.238931
Paktak	Khost	Shamal	no	12	0.409	0.234536
Khwajakhel	Logar	Logar Lower	no	12	0.414	0.245451
Rabat	Paktya	Chamkani	yes	12	0.423	0.270931
Khushhalkhel	Logar	Azrow	yes	12	0.427	0.250709

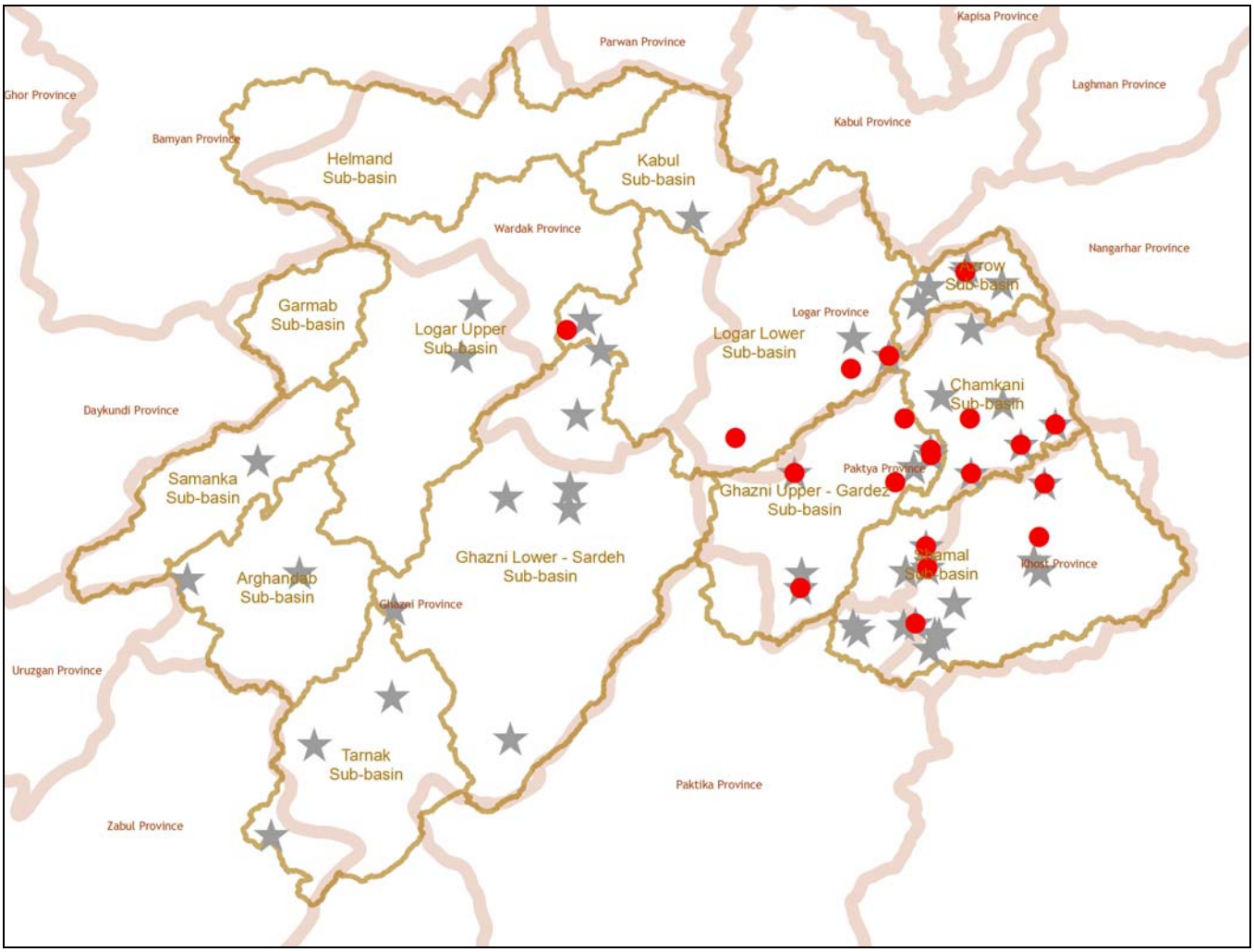

Figure 6. Bottom 20 Irrigation Storage Dam Projects (with gray stars indicating unstable sites).

To focus on the factors responsible for the patterns shown above, the contribution of project criteria was separated from watershed criteria. The field "Project Results" in Table 7 in Appendix O was used for this comparison. Criteria in the groups Project Efficiency and Impacts/Benefits only were used to create that partial rating, using the weights in Table 1.

Figure 7 contains the symbolized ratings using only the project and impact criteria for 12m dams. Compare this with the Figure 4 shown above. The sites in the southwest have relatively poor summary ratings, and those in the northeast have relatively high ratings. Looking at the project contribution indicates there is not the same pattern. Relatively poor projects in terms of efficiency, cost, storage potential, and irrigation benefits are scattered throughout. Figure 8 shows only the watershed criteria for the same projects. The pattern is similar to that in Figure 4, indicating the higher quality of the watershed factors makes up for differences in project attributes, causing the higher total ratings pattern.

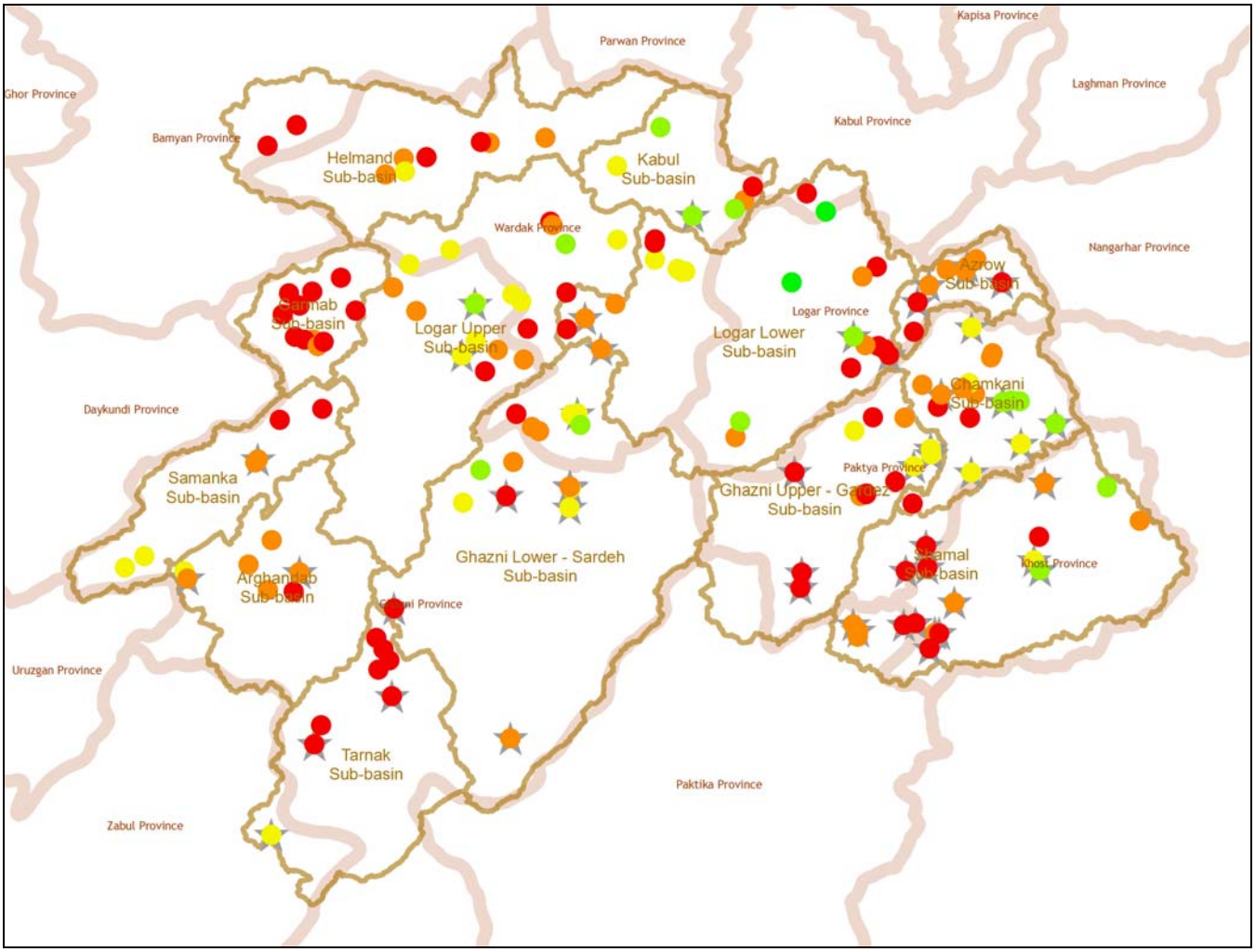

Figure 7. 12m Irrigation Storage Dam Ratings without Watershed criteria

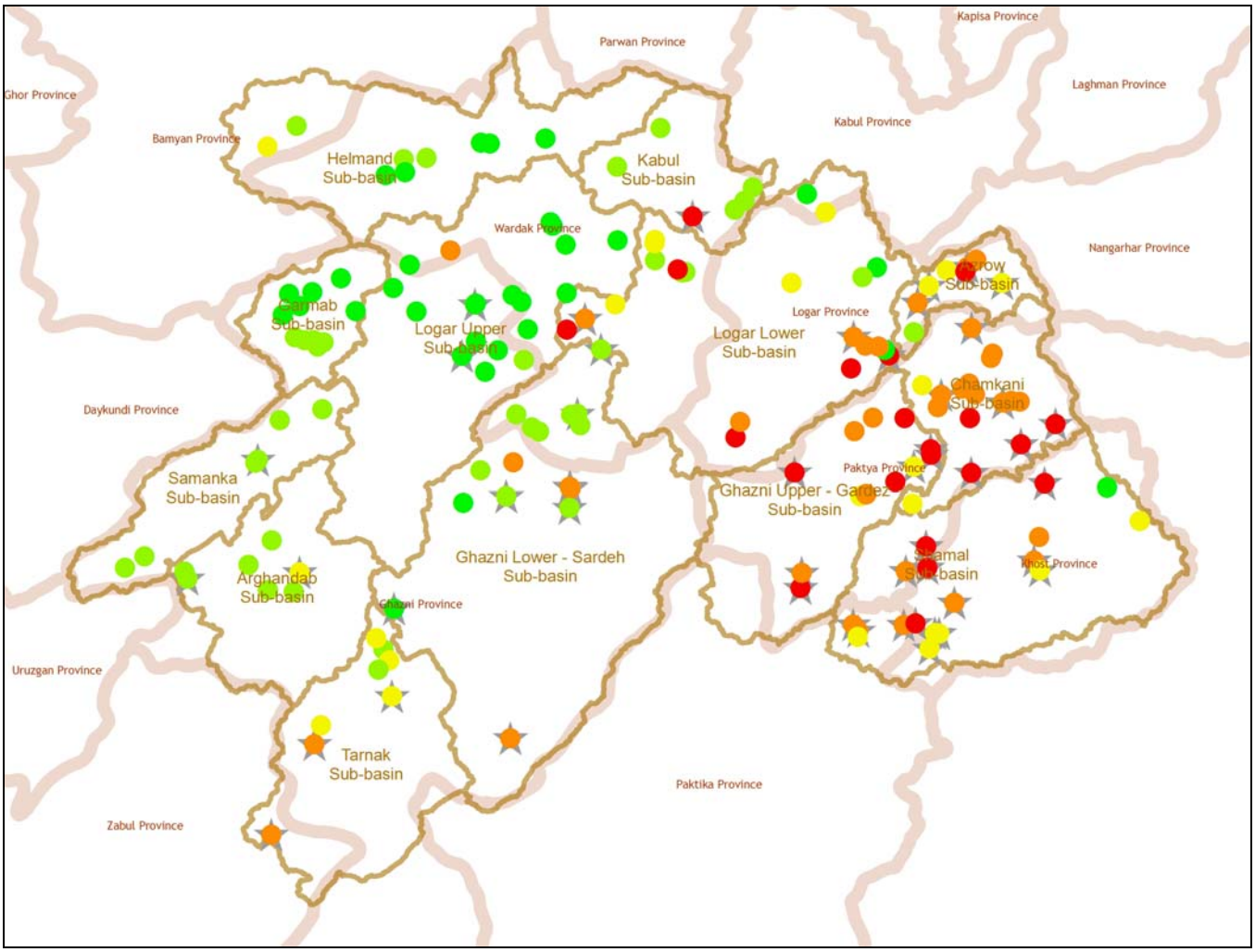

Figure 8. 12m Irrigation Storage Dam Ratings Watershed Criteria Only

It may be of interest to discover what projects have the highest rating considering dam height, since storage efficiency and other project factors may vary somewhat within a project, depending on pool size, construction volume, and other criteria. Table 5 contains the top 20 results, not filtered by dam height.

Table 5. Top 20 Irrigation Storage Dam Projects (all dam heights)

Name	Province	Sub_Basin	Height	Results	UnstableSite
Shaghasi Kala	Logar	Logar Lower	Max	0.812	no
Dehbakhshi	Ghazni	Ghazni Lower-Sardeh	12	0.7805	yes
Dehbakhshi	Ghazni	Ghazni Lower-Sardeh	Max	0.7805	yes
Dehbakhshi	Ghazni	Ghazni Lower-Sardeh	5	0.7805	yes

Dehbakhshi	Ghazni	Ghazni Lower-Sardeh	8	0.7805	yes
Kunj	Kabul	Logar Lower	12	0.768	no
Kunj	Kabul	Logar Lower	8	0.758	no
Shaghasi Kala	Logar	Logar Lower	12	0.745	no
Shaghasi Kala	Logar	Logar Lower	8	0.723	no
Kunj	Kabul	Logar Lower	5	0.707	no
Gurgkushta	Ghazni	Logar Upper	5	0.705	yes
Lashkari	Wardak	Logar Upper	8	0.701	no
Niw Qal'a #2	Ghazni	Logar Upper	12	0.7005	yes
Lashkari	Wardak	Logar Upper	5	0.699	no
Shaghasi Kala	Logar	Logar Lower	5	0.699	no
Lashkari	Wardak	Logar Upper	12	0.698	no
Sinak	Wardak	Helmand	5	0.696	no
Niw Qal'a #2	Ghazni	Logar Upper	8	0.6945	yes
Bokan	Ghazni	Logar Upper	5	0.693	no
Niw Qal'a #2	Ghazni	Logar Upper	Max	0.6905	yes