Appendix N: Results for Watershed Restoration Potential Decision Model

Potential for watershed restoration is influenced by the condition of the watershed stream system, overall active erosion, and degree of deforestation in forested areas. A higher rating indicates a higher proportion of actively-eroding upland with more opportunities for upland restoration and more potential for reforestation projects at higher elevations. A relatively stable stream system increases the opportunities for streambank restoration projects, and increases chances of their success. Finally, local population and existing agricultural infrastructure make any project more beneficial. *Subject to other considerations (such as security, access, and remoteness) these are the likely places where watershed restoration would be successful.*

To remotely prioritize the 295 proposed project watersheds we developed a structured decision support model, based on data gathered in the assessment. Since it is based on consistently measured watershed properties it should be used to help guide watershed restoration efforts on the ground. It is not site-specific. The advantages of using it include systematic and consistent rating for each of many projects, repeatability and documentation, the ability to modify the rating system as circumstances change, and the ability to include subjective weights to modify the objective data in the rating system.

Ratings are based on a decision support model with four criteria. Each has a rating scale. Three are standard (higher values give higher ratings), and one (stream system instability) is 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 rating for the project watershed.

Figure 1 shows the decision support model with attached weights for each criterion. For this model each of the main criteria (Deforestation, Stream System Instability, Potential Agro-benefits, and Upland Erosion) are weighted equally.

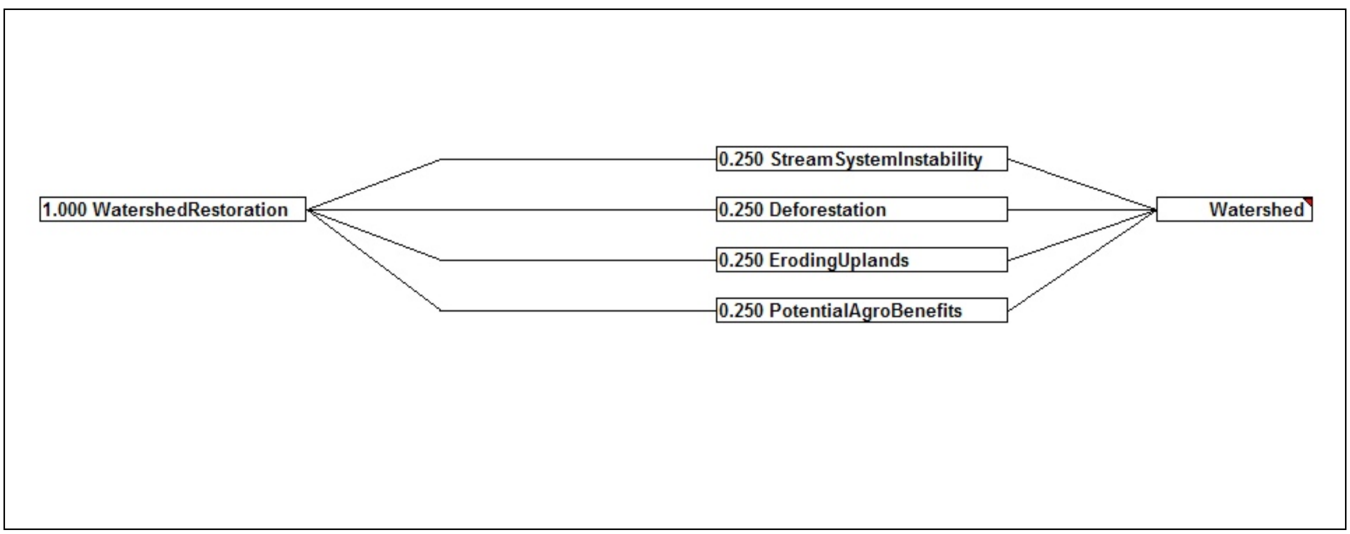

Figure 1. Decision Support Model for Restoration

Each criterion and the rating system for it are described below.

StreamSystemInstability: This rating reflects the instability of stream systems, which influence sediment and flooding, as well as bank vegetation and channel character. See Section 4.4.2 Stream System Characterization in the main document for details on evaluating this factor. See Figure 2 and Figure 3 for an example of unstable and stable systems, respectively. Note in Figure 2 two dates of imagery showing large flow differences between spring and summer flows and the wide, unstable flood plain. This limits the success and increases the scope of any proposed streambank restoration projects. Projects in areas similar to Figure 3 may have greater success.

This criterion uses an inverse scale with lower values of instability indicating a higher likelihood of conditions favoring successful stream system restoration.   Rating endpoints come from the range of available data.

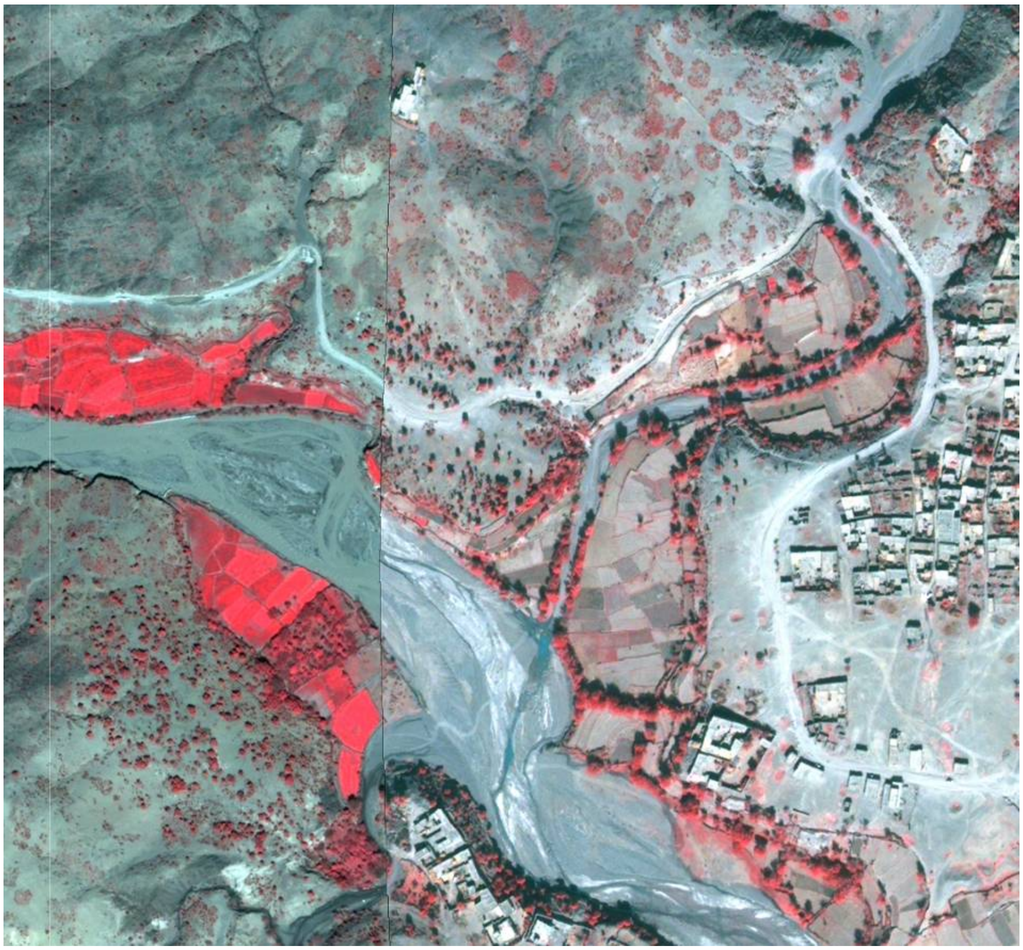

Figure 2. Unstable stream system

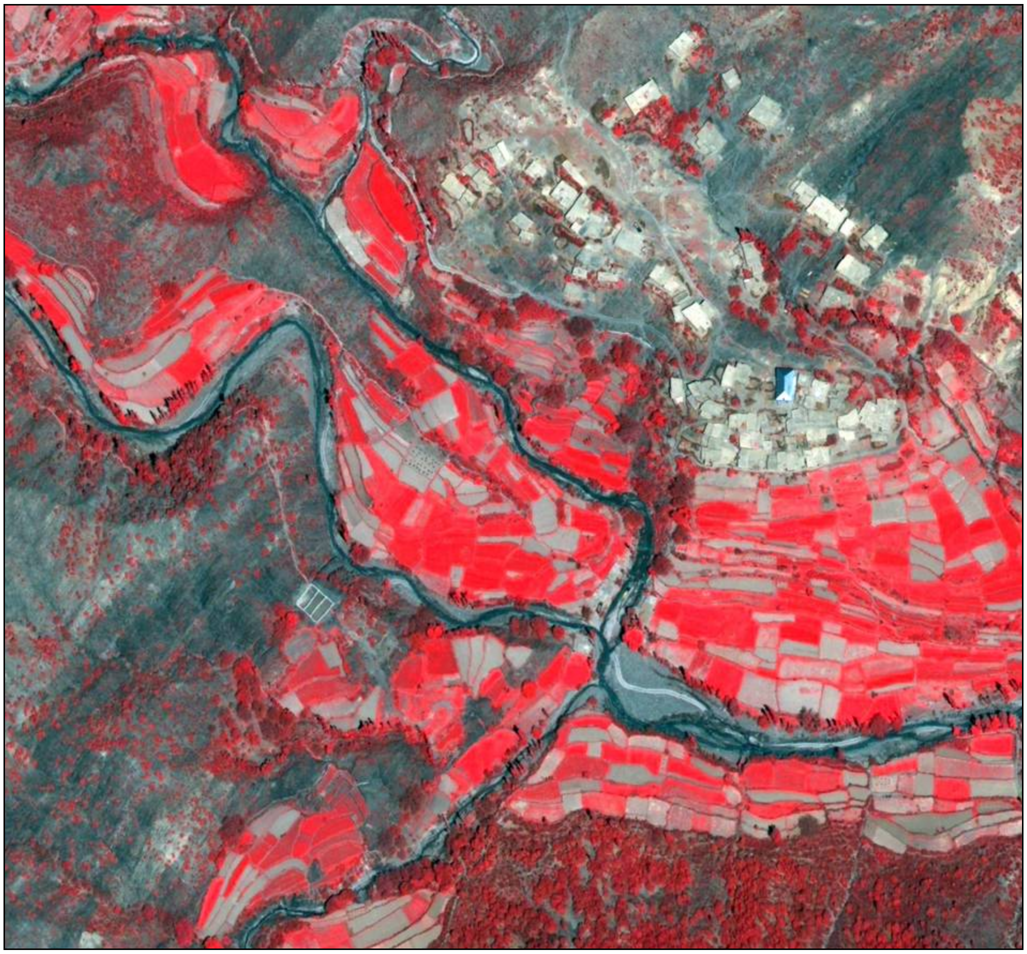

Figure 3. Example of Stable Stream System

Deforestation: Deforestation affects watersheds by increasing sedimentation and peak flows, reducing the probable success of streambank restoration projects. However, since deforestation also increases the chances of reforestation opportunities, it is used here as a positive indicator. See Section 4.4.1 Deforestation in the main document for details on evaluating this factor. See Figure 4 for an example. 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 standard with higher values resulting in higher ratings. Rating endpoints come from the range of available data.

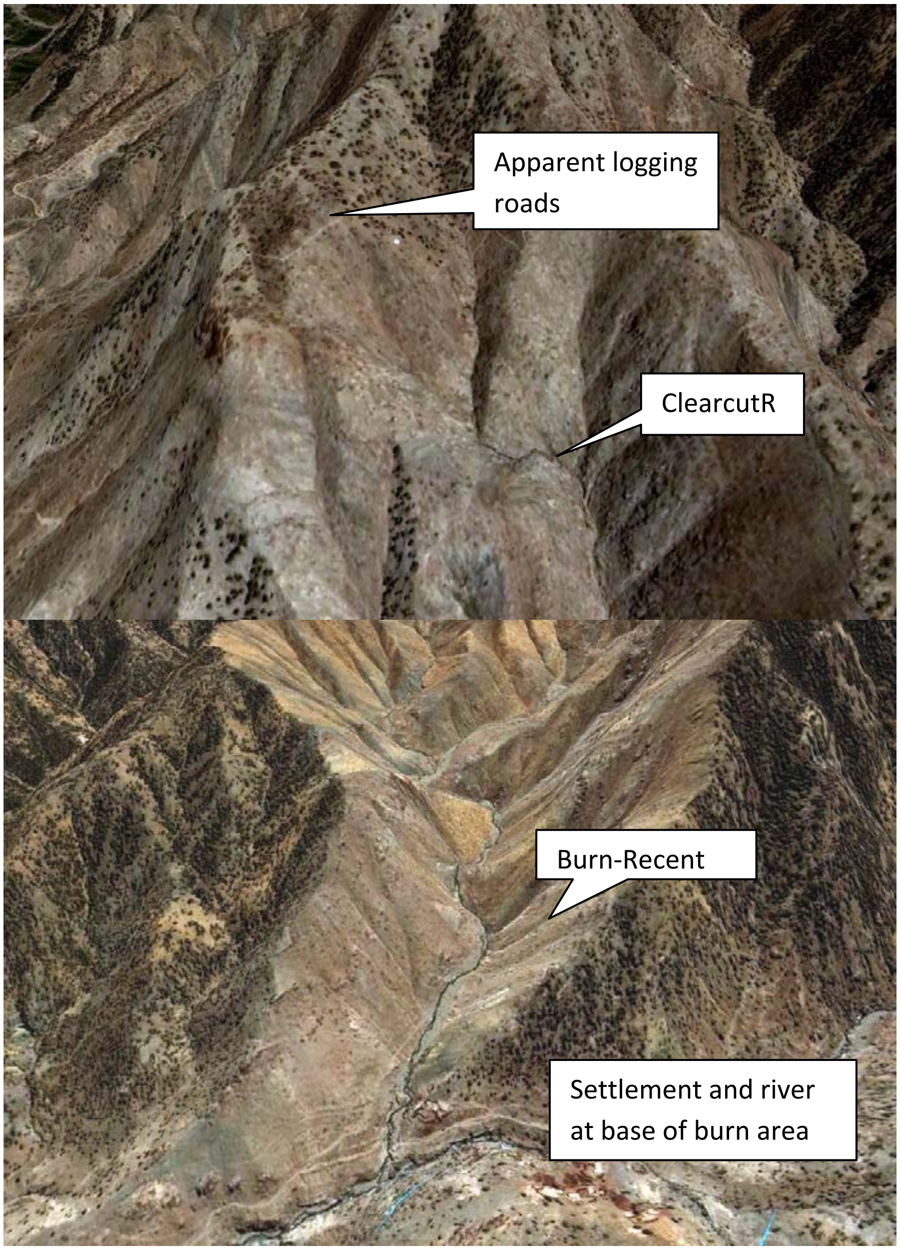

Figure 4. Illustrations of Deforestation

ErodingUplands: Eroding lands are those uplands that have active gullying and rill erosion. They are related to relatively erodible soils, slope, climate, and poor land use practices. See Section 4.4.4 Active Upland Gully Erosion in the main document for details on evaluating this factor. See Figure 5 for an example. A higher proportion of eroding lands gives more opportunity for upland restoration projects. The scale is standard, with higher values giving higher ratings. Rating endpoints come from the range of available data.

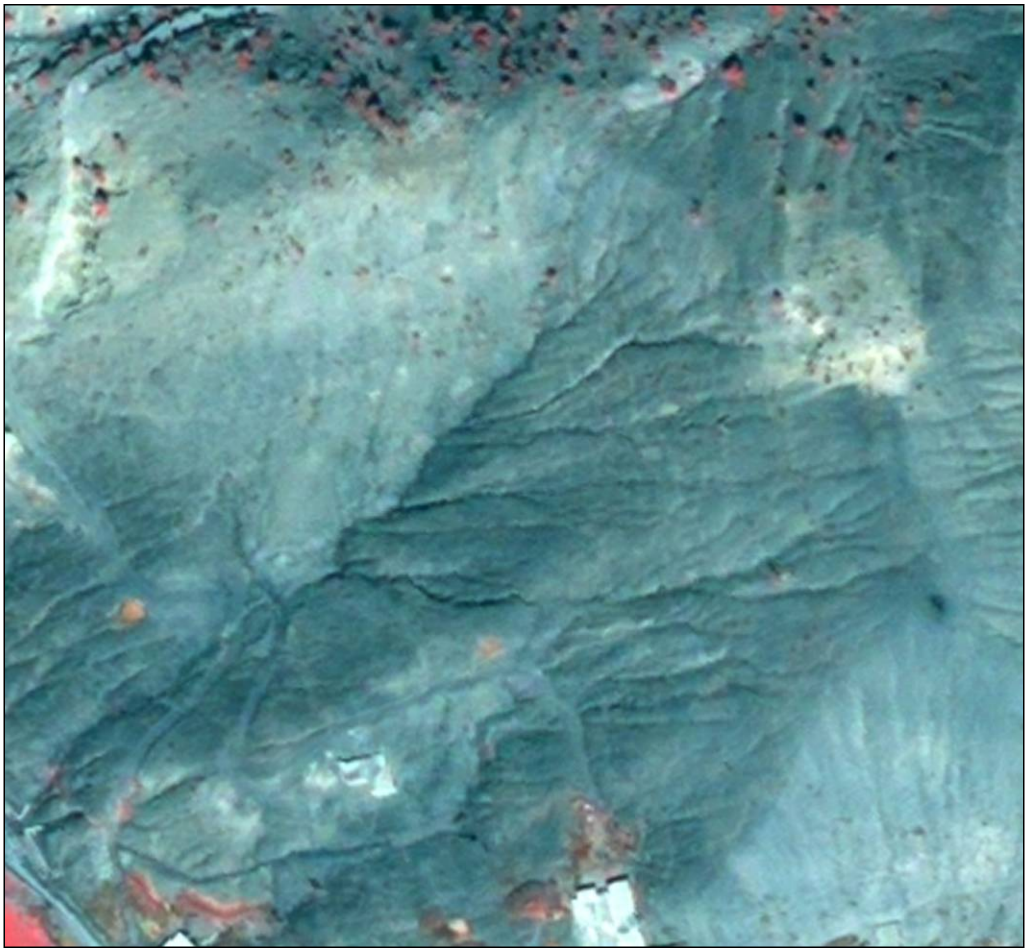

Figure 5. Active Gully Erosion (scale about 1:3000)

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. See Section 4.4.6 Environmental Impacts – Irrigated land in the main document for details on evaluating this factor. See Figure 6 for an example. Reddish areas are probable irrigated lands. A higher area of irrigated land indicates a higher benefit. Rating endpoints come from the range of available data.

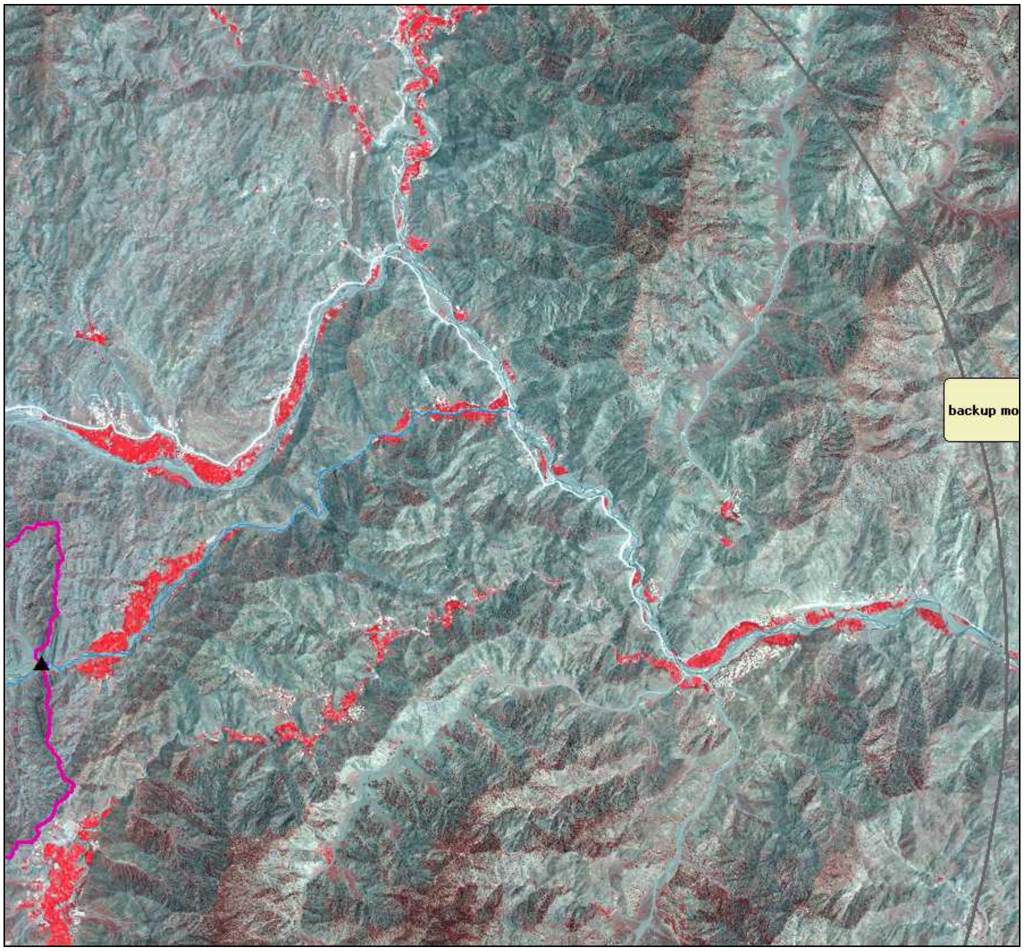

Figure 6. Example of Irrigated Agriculture (scale about 1:40000).

Each rating, field data name, weights, and data ranges are in Table 1. The Data Field Name is the dBase-compatible field used in acquiring data values. These 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). The DCP Name field contains those normalized results. Ranges of data come from data from the 295 project watersheds (Table 12, Appendix O). Weights are from the decision model (Figure 1).

Table 1. Watershed Restoration Decision Support Model Rating Specifications

DCP Name	Data Field Name	Weights	Units	Low Limit	High Limit	Range	Scale
UnstableStreamSystem	UNSTSTRS	0.25	%	0	100.0	100.0	reverse
Deforestation	DEFORESTN	0.25	%	0	30.3	30.3	standard
ErodingUplands	ERODNGLN	0.25	weighted %	15.3	44.5	29.2	standard
PotentialAgroBenefits	POTAGBNF	0.25	Ha	0	1,888.0	1,888.0	standard

Table 10 in Appendix O contains the project name, the ratings ("Results"), all the criterion values, and area by watershed in Ha. For each criterion, the first field name is the decision support model criterion (e.

g. StreamSystemInstability), and contains the normalized value (before weighting). The succeeding Dbase-compatible name contains the raw data score (e.g. UNSTRSRS). The first value in each pair is multiplied by the associated weight from Table 1 and summed with the other three to form the total rating score.

Figure 7 shows the 295 project locations and their associated watersheds. Project location is symbolized by green dots and associated watershed by gray delineation. Strong brown polygons outline study sub-basins, and faint brown lines show province boundaries.

There is overlap on many watersheds, since they were delineated after project identification, so there will also be some overlap on watersheds rated for restoration or any other factor. Secondly, watershed size varies widely, depending on the project, so this limits direct comparison by watershed size.

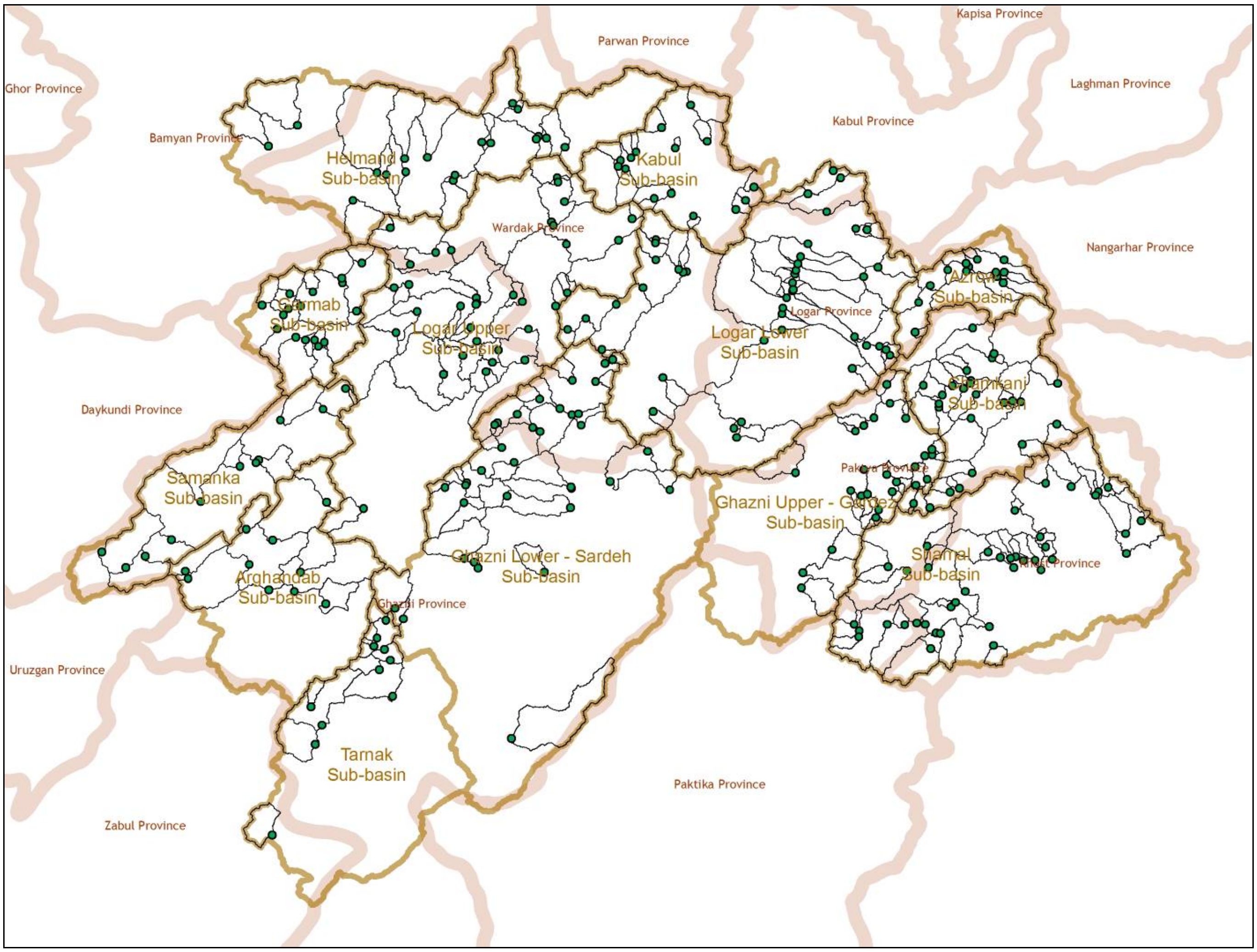

Figure 7. Project Watersheds and Project Locations

Project locations symbolized by watershed restoration rating are in Figure 8. Data is from the Results field in Table 10, Appendix O. The color green indicates the highest potential, and the color red indicates the least potential. Ratings of these projects are all relative. That is, the system rates from "best" to "worst". Most of Afghanistan has challenges respective to watershed condition. It would be hard to find a watershed in "good" condition as is defined over most of the world. However, this rating system can still help focus efforts to improve the situation. The Shamal, Helmand, and Logar Upper sub-basin watersheds appear to have the greatest potential in terms of opportunities for restoration. However, there are some limitations to this evaluation. Watersheds were evaluated only if they had a prospective project associated with them, which biases the spatial distribution of results. Though the display can show trends, a better usage may be to use these data to select the best watersheds for further evaluation, as described below.

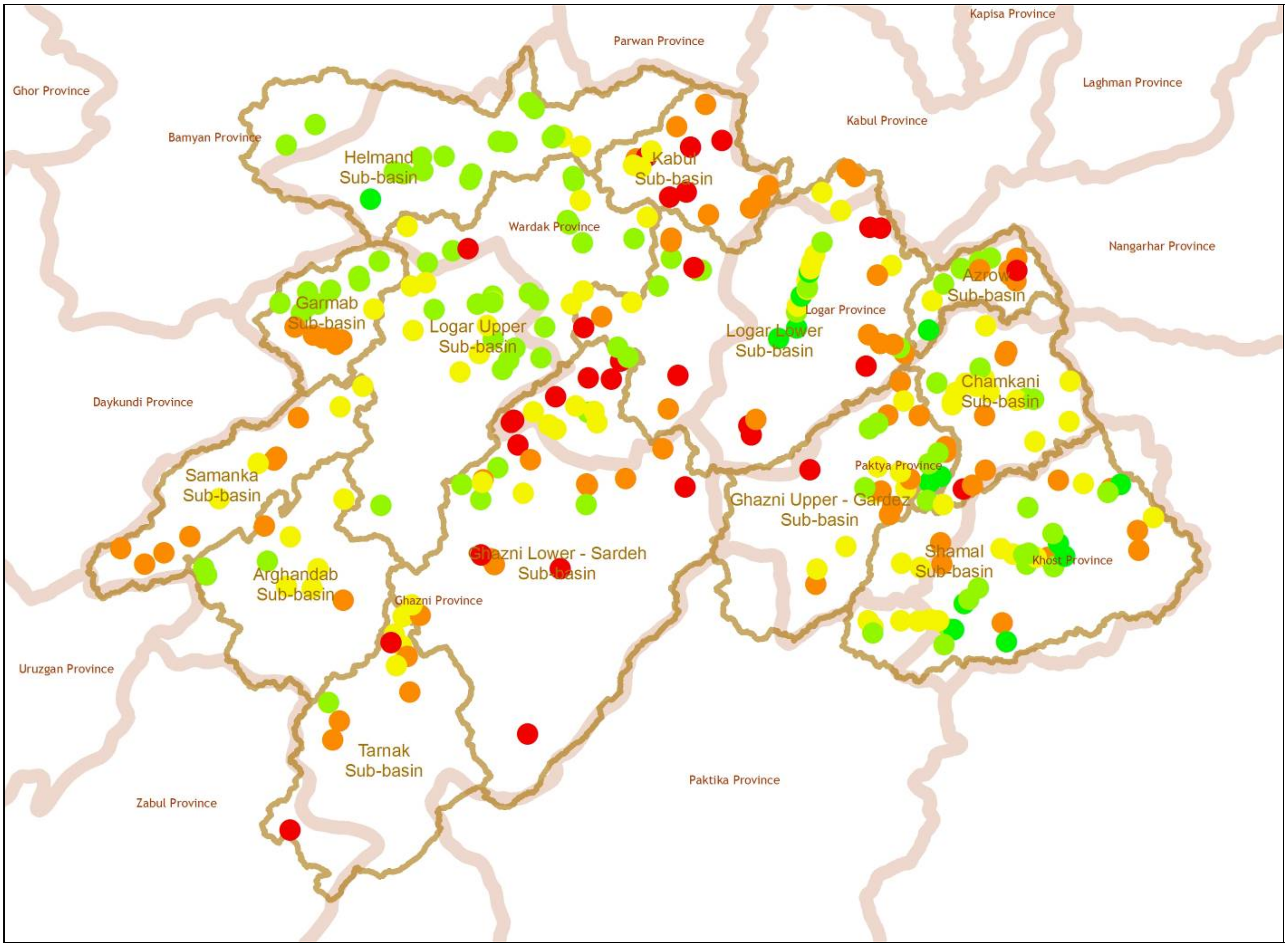

Figure 8. Watershed Restoration All Ratings

Table 2 shows just the top 20 rated project watersheds, taken from Table 10, Appendix O. This list is used to focus on the best project watershed restoration areas. Table 3 shows the 20 project watersheds having the least potential for restoration.

Table 2. Top 20 Watersheds for Restoration Potential

Name	Province	Sub_Basin	NameLegal	StreamSystemInstability	ErodingUplands	Deforestation	PotentialAgroBenefits	Results
Kamkay Mazghar	Khost	Shamal	Kamkay Mazghar	0.494	0.904	0.159	0.709	0.567
Waghjan	Logar	Logar Lower	Waghjan	1	0.79	0	0.471	0.565
Wargha	Khost	Shamal	Wargha	0.486	0.894	0.152	0.709	0.56
Shadal	Khost	Shamal	Shadal	0.439	0.9	0.717	0.063	0.53
Khatinkhel	Khost	Shamal	Khatinkhel	0.78	0.846	0.378	0.038	0.51
Abbas Koshteh	Wardak	Helmand	Abbas Koshteh	1	0.98	0	0.017	0.499
Narezah	Khost	Shamal	Narezah	0.3	0.673	0.976	0.047	0.499
Dam	Paktya	Ghazni Upper-Gardez	Dam	1	0.845	0	0.137	0.495
Ghunday	Paktya	Ghazni Upper-Gardez	Ghunday	1	0.901	0	0.075	0.494
Zer Kac	Logar	Azrow	Zer Kac	1	0.911	0	0.011	0.48
Puli Alam	Logar	Logar Lower	Puli Alam	0.451	0.464	0	1	0.479
Baak #2	Khost	Shamal	Baak #2	1	0.619	0	0.22	0.46
Qal'eh-ye Khwaja	Logar	Logar Lower	Qaleh-ye Khwaja	1	0.419	0	0.405	0.456
Taqi	Logar	Logar Lower	Taqi	0.629	0.514	0	0.658	0.45
Mana	Khost	Shamal	Mana	0.705	0.883	0.154	0.035	0.444
Shinah	Wardak	Helmand	Shinah	0.911	0.767	0	0.083	0.44
Acarkhel	Khost	Shamal	Acarkhel	0.76	0.896	0.058	0.033	0.437
Dawlatzi	Paktya	Ghazni Upper-Gardez	Dawlatzi	0.894	0.75	0	0.086	0.433
Laki Babakhel #1	Wardak	Ghazni Lower-Sardeh	Laki Babakhel #1	1	0.7	0	0.029	0.432
Nayjoy	Ghazni	Garmab	Nayjoy	1	0.698	0	0.016	0.429

Table 3. Bottom 20 Watersheds for Restoration Potential

Name	Province	Sub_Basin	NameLegal	StreamSystemInstability	ErodingUplands	Deforestation	PotentialAgroBenefits	Results
Aynak	Logar	Logar Lower	Aynak	0	0.012	0	0	0.003
Baha'ijan Kor	Logar	Logar Lower	Bahaijan Kor	0	0.091	0	0	0.023
Qolak	Wardak	Kabul	Qolak	0	0.037	0	0.193	0.057
Sar-e Tup	Wardak	Logar Upper	Sar-e Tup	0	0.162	0	0.108	0.068
Dara-i Zyarat	Wardak	Kabul	Dara-i Zyarat	0	0.1	0	0.237	0.084
Shotan	Ghazni	Ghazni Lower-Sardeh	Shotan	0	0.433	0	0.045	0.12

Mohammad-Khel #2	Logar	Azrow	Mohammad-Khel #2	0.374	0.1	0	0.021	0.124
Wet	Ghazni	Ghazni Lower-Sardeh	Wet	0.069	0.394	0	0.043	0.127
Dahana	Wardak	Ghazni Lower-Sardeh	Dahana	0	0.494	0	0.024	0.129
Nyazullah	Ghazni	Ghazni Lower-Sardeh	Nyazullah	0	0.428	0	0.097	0.131
Ampurak	Wardak	Ghazni Lower-Sardeh	Ampurak	0	0.486	0	0.074	0.14
Chambare Warqa	Ghazni	Tarnak	Chambare Warqa	0	0.501	0	0.06	0.14
Babur	Wardak	Ghazni Lower-Sardeh	Babur	0	0.537	0	0.026	0.141
Abchakan	Logar	Logar Lower	Abchakan	0	0.58	0	0.012	0.148
Khwajakhel	Logar	Logar Lower	Khwajakhel	0	0.555	0	0.065	0.155
Chalakhel	Logar	Logar Lower	Chalakhel	0.215	0.316	0	0.093	0.156
Karakat	Wardak	Logar Lower	Karakat	0	0.599	0	0.04	0.16
Mayana	Wardak	Ghazni Lower-Sardeh	Mayana	0	0.585	0	0.082	0.167
Tangi Kholeh	Wardak	Kabul	Tangi Kholeh	0.088	0.384	0	0.2	0.168
Merzaka	Ghazni	Ghazni Lower-Sardeh	Merzaka	0.228	0.407	0	0.051	0.171

Figure 9 shows the top and bottom rated watersheds in the Study Area. There is some overlap in watershed area, but the image still shows the best areas to focus restoration efforts and the areas that may have lower opportunities for success. Best opportunities for further watershed evaluation or focus of resources may be in Shamal, Helmand, and Logar Lower, with less opportunity in Ghazni Lower.

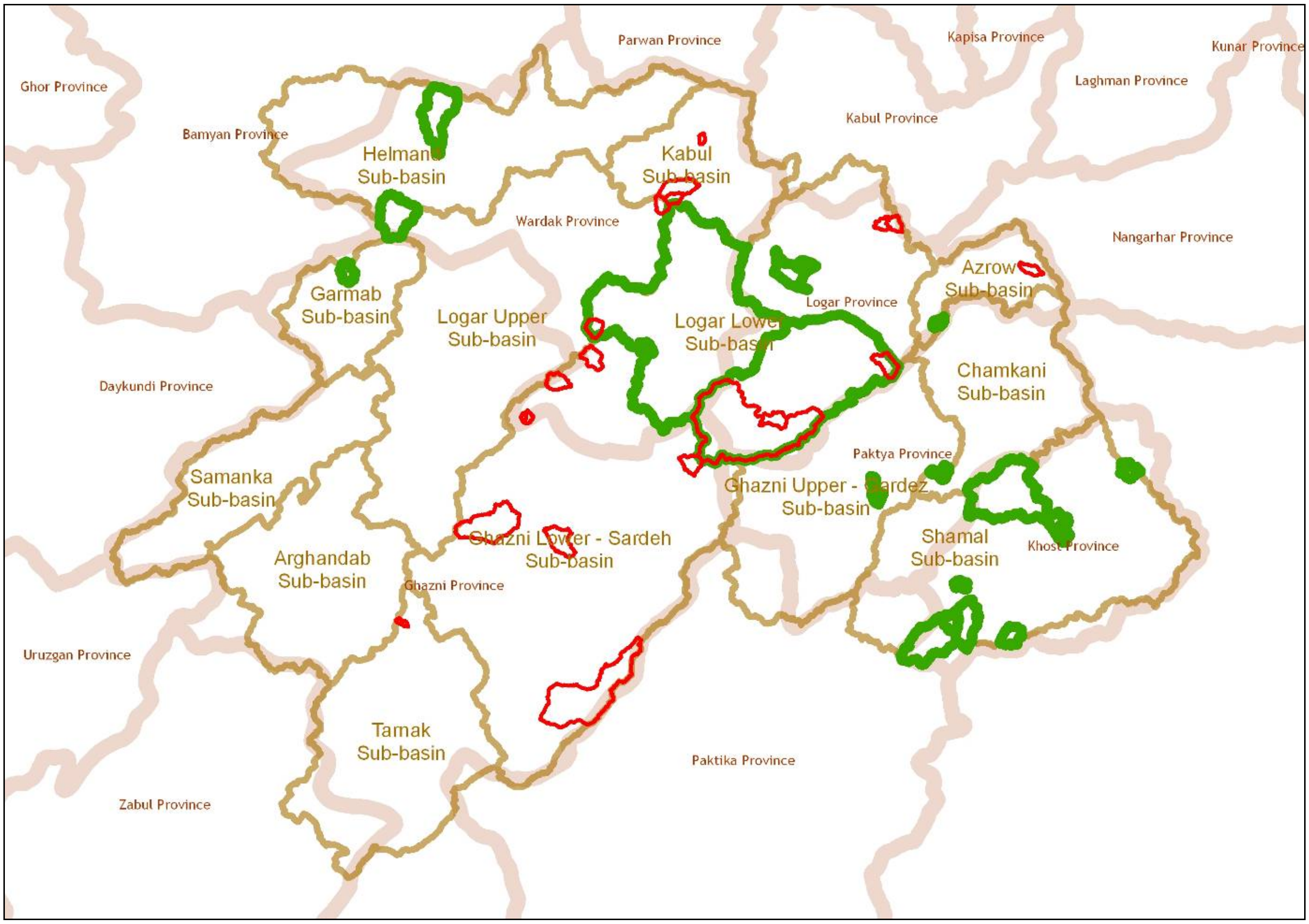

Figure 9. Top and Bottom Rated Watersheds for Restoration Potential

To illustrate the rating process, the following shows close-ups of "low" and "high" rated watersheds, with their associated criteria data. Figure 10 shows two highly-rated watersheds. See Table 2 for descriptions. Red hatching indicates high upland erosion. Recent deforestation is present (brown), and the stream system is only partially stable (stable is delineated as all other colors save red), and there is significant downstream irrigation associated with the watershed (blue delineations).

Figure 10. Highly-rated Restoration Watershed Example

Figure 11 shows two watersheds rated poorly for restoration potential. See Table 3 for descriptions of these watersheds. Green indicates low upland erosion. There is no recent deforestation and stream systems are primarily unstable (red delineations). There is only a small area of downstream irrigation (blue polygons), indicating low population.

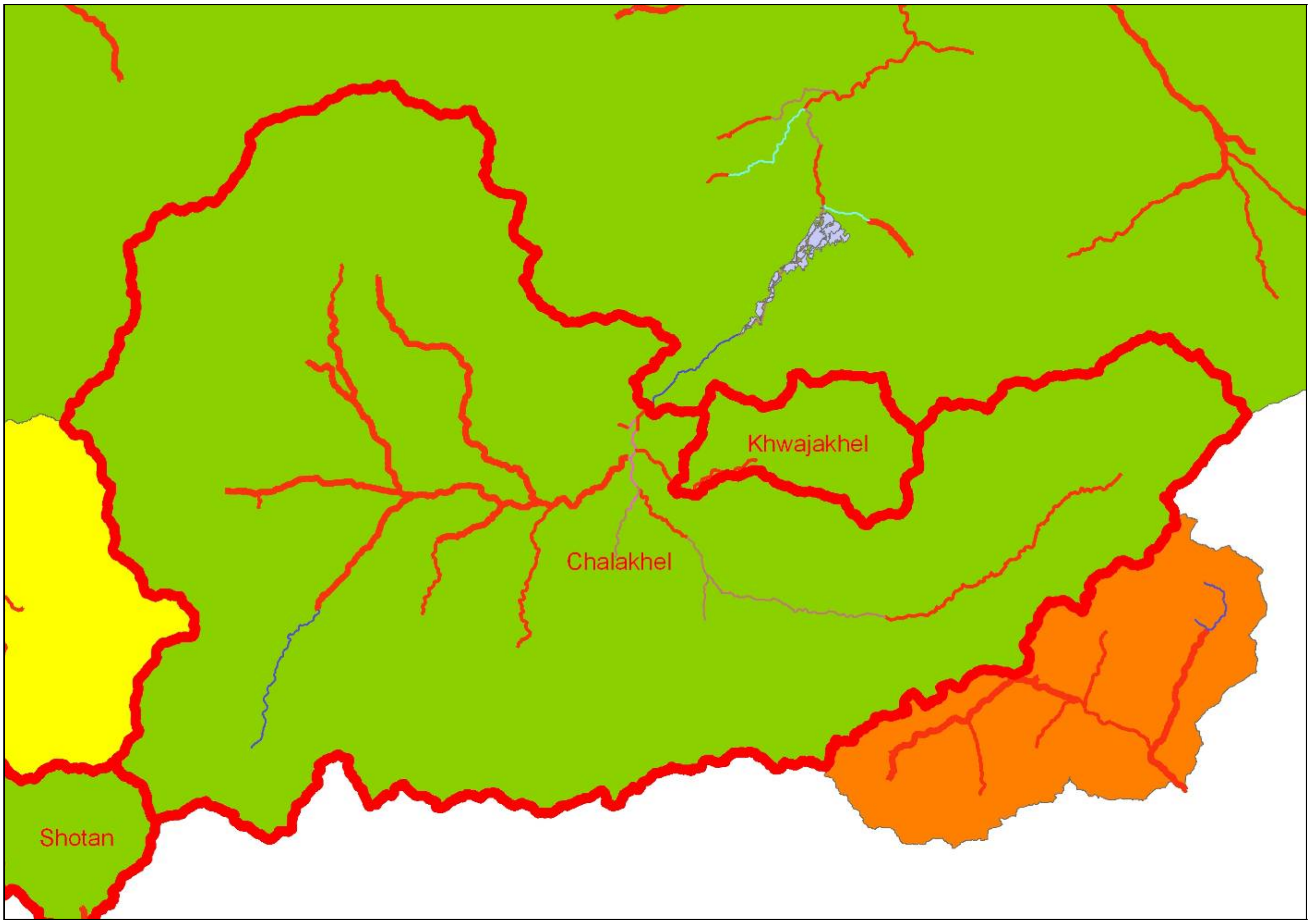

Figure 11. Low-rated Restoration Watershed Example

Of course other considerations can be used to further refine or re-rate the watersheds. As an example, Figure 12 shows the top and bottom 20 watersheds rated without the Potential Agro-Benefits criterion. This, when compared with Figure 9, shows the effect of excluding the effects of affected population for the model. There is a distinct change in pattern when using potential human benefits, rather than just the natural resource aspects (stream instability, deforestation, and erosion). Smaller watersheds are emphasized when removing the effects of population, probably due to the correlation between size of stream and irrigation potential.

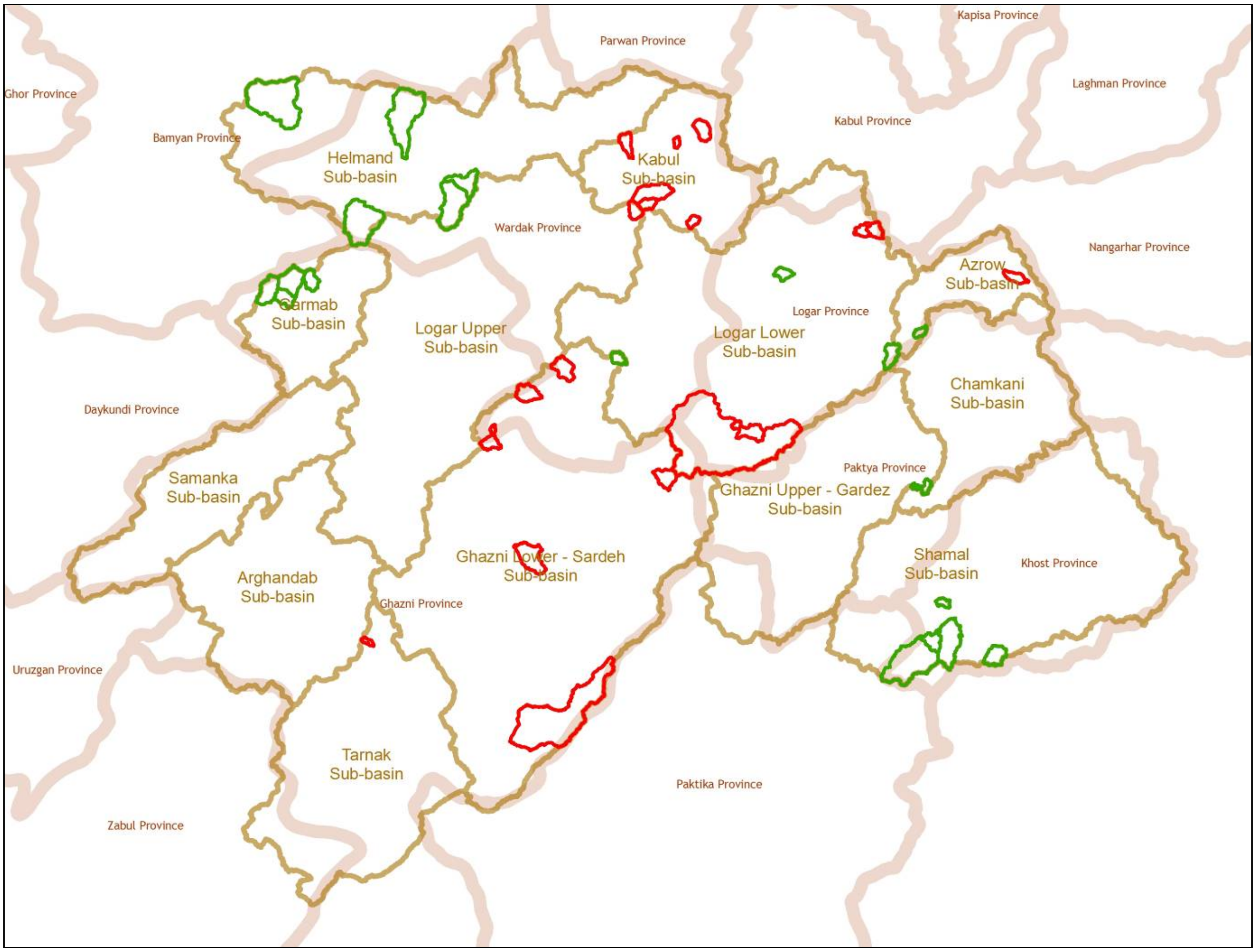

Figure 12. Top and Bottom Rated Watersheds for Restoration Potential without Benefits

In summary, location of restoration projects depends on many factors, and many cannot be quantified as was done in the decision support model. For example, vegetation cover was not used in this model. In reality, many watersheds having “rangeland” as their primary land cover (See Appendix O, Table 3) may be very arid areas (such as Ghazni Lower-Sardeh and Tarnak sub-basins). Based on review of the imagery, these areas have almost no vegetation to restore. This could be added as a factor with additional analysis. However, using the above model can help focus potential areas, freeing up decision makers to use those “other” factors more clearly, rather than just “shooting in the dark” when prioritizing expensive and potentially dangerous field work.