CASP+ Annex 18f:
Rapid assessment of pasture conditions in IFAD-funded project areas

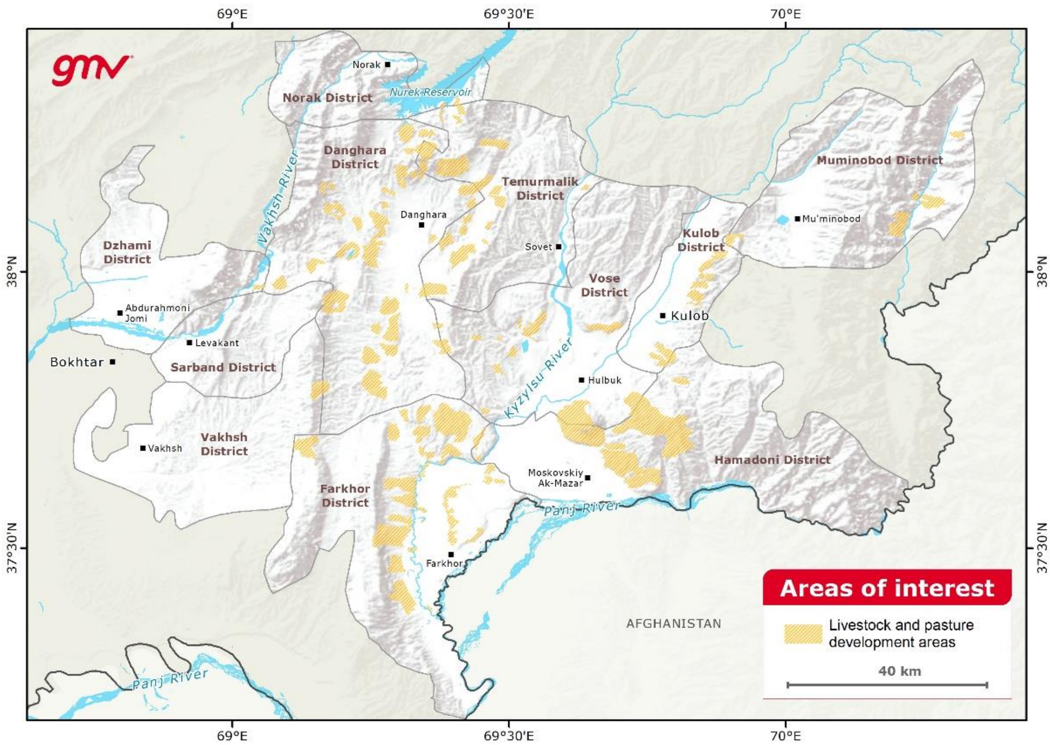
Pasture degradation in the Livestock and Pasture Development Programme – Phase II (LPDP II) intervention areas (2000-2021)

This note presents the evolution of pasture degradation between 2000 and 2021 in the pasture under direct control and management of the beneficiaries of the Livestock and Pasture Development Programme Phase II (LPDP II[1]), within the Khatlon region. The geospatial analysis supporting this document was conducted by GMV[2], contracted by IFAD to assess the impact of the LPDP II project on pasture degradation in the Khatlon region.

1. LPDP II Pasture Plots

The area of analysis of document comprises LPDP II pasture plots. The identification of these areas is based on the project-facilitated georeferenced identification of pasture under the influence of the Pasture User Unions (PUUs) beneficiaries of the LPDP II. They represent a total area of 65 657 ha, all within the Khatlon region. These plots are presented in Figure 1.

Figure 1 – LPDP II Plots



[1] https://www.ifad.org/en/web/operations/-/project/2000000977
[2] https://www.gmv.com/en/sectors/space

2. Methodology

2.1. *Temporal range*

The analysis[3] of the pasture condition changes over the period 2000-2021 was carried out by considering averages over three periods: **a/** the baseline period (2000-2004), **b/** pre IFAD-financed intervention (2016-2020), and **c/** Post IFAD-financed intervention (2020-2021).

Because the methodology used in this analysis only yields degradation trends and not degradation "states" (see "processing steps" below), the assessment of the impact of the LPDP II project on pasture degradation was carried out by comparing two degradation trends:

- The 2000-2004 vs 2016-2020 degradation trend (pre-IFAD intervention)
- The 2000-2004 vs 2020-2021 degradation trend (post-IFAD intervention)

2.2. *Processing steps*

The analysis relied on satellite imagery, atmospherically and radiometrically corrected, from Landsat-5, -7 and -8.

The spectral bands of the imagery acquired from the different sensors had distinct bandwidths, thus the first step was to adjust reflectances radiometrically in order to ensure time series consistency. In this procedure, radiometrically stable targets, e.g. bare soil, were selected and used as reference for the inter-calibration exercise.

Secondly, the spectral indices from Table 1 below are calculated for each grazing season period in each five-year timeframe. These indices are used as proxy to assess the grassland changes over time. However, it is the maximum value for each index of 15-days averages over the grazing periods the metric used for analysing condition changes of the grasslands in the two periods.

The changes observed in the two periods by the different indexes are combined to estimate the rangeland condition changes. Before combining, we analysed not only the autocorrelation of the indices but also the significance of each of them for monitoring the state of the rangelands. These two analyses are independently performed for every grazing seasonal area. Indices with observed similarity greater than 75% are discarded. Regarding the significance, a random forest feature importance calculation was performed. The non-correlated rangelands changes products were weighted by the importance of each index and combined applying a weighted sum model (Eq. 1). This approach is widely used in geospatial applications (Belenguer-Plomer 2016; Rahman and Saha 2008). Additionally, a level of confidence product was also derived considering the weighted differences of each index-based product with respect to the combined result.

$$Rangeland\ condition\ changes_i = \sum_{j=1}^{n} w_j c_{ji} \qquad (1)$$

where i is a single geospatial observed unit (i.e., an image pixel), n is the number of considered indices, w is the weight of the index j and c is the qualitative class of the rangeland condition change of the index j.

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[3] Done by the Climate Resilience Cluster of the EO4SD.

Table 1 - Indices considered for estimation of the changes in rangelands condition

Index	Formula[4]	Reference
NDVI *Normalized Difference Vegetation Index*	$\frac{NIR - RED}{NIR + RED}$	(Rouse Jr et al. 1974)
EVI *Enhanced Vegetation Index*	$G \times \frac{NIR - RED}{NIR + C1 \times RED - C2 \times BLUE + L1}$	(Liu and Huete 1995)
SAVI *Soil Adjusted Vegetation Index*	$\frac{NIR - RED}{NIR + RED + L2} \times 1 + L2$	(Huete 1988)
MSAVI *Modified Soil Adjusted Vegetation Index*	$\frac{2 \times NIR + 1 - \sqrt{(2 \times NIR + 1)^2 - 8 \times (NIR - RED)}}{2}$	(Qi et al. 1994)
NDMI *Normalized Difference Moisture Index*	$\frac{NIR - SWIR_1}{NIR + SWIR_1}$	(Gao 1996)
NBR *Normalized Burn Ratio*	$\frac{NIR - SWIR_2}{NIR + SWIR_2}$	(López-García and Caselles 1991)
NBR2 *Normalized Burn Ratio 2*	$\frac{SWIR_1 - SWIR_2}{SWIR_1 + SWIR_2}$	(Key and Benson 2004)
VCI *Vegetation Condition Index*	$\frac{NDVI_i - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$	(Kogan 1990)
VHI *Vegetation Health Index*	$\frac{VCI + TCI}{2}$	(Kogan 1995)

The rangeland condition changes were reported as degradation levels following the IPCC's guidelines of grasslands degradation (Table 2).

Table 2 - Classes of rangeland condition changes from IPCC's guidelines

Qualitative classes	Index variation of post-period with respect to pre-period
Severely degraded	<70%
Moderately degraded	70.1-95%
Non-variation	95.1-105%
Enhancement	>105%

This analysis was applied for two time periods (2000-2004 vs 2016-2020 (pre-IFAD intervention) and 2000-2004 vs 2020-2021 (post-IFAD intervention)) within the LPDP II plots, focusing on 5 periods: spring, summer, autumn winter, and all seasons (all year round).

[4] RED, NIR, BLUE, SWIR1 and SWIR2 correspond to bands 3, 4, 1, 5 and 7 as well as 4, 5, 2, 6 and 7 for Landsat-5 -7 and Landsat-8, respectively. When computing the EVI and SAVI G is 2.5, C1 is 6, C2 is 7.5, L1 is 1 and L2 is 0.2, respectively. Regarding the VCI, i refers to a specific date of a considered temporal period. Finally, TCI is the Thermal Condition Index, expressed as $(LST_i - LST_{min})/(LST_{max} - LST_{min})$, where LST is the Landsat-based Land Surface Temperature.

The 10 maps produced were than compared pairwise to build the final maps. If the degradation trend was steeper post-IFAD intervention than pre-IFAD intervention, a downward trend was marked. If the degradation trend was milder post-IFAD intervention than pre-IFAD intervention, an upward trend was marked.

3. Results

The result of the analysis for each season is presented in Figure 2 to Figure 6. Key findings of LPDP-II investment effects on pasture can be summarized as:

- **Generalized lower degradation patterns**: Most of the pastures presented a less intense degradation trend post IFAD intervention, especially in all seasons, spring, summer, and winter pastures.
- **No change or slight degradation on autumn pastures**: The IFAD intervention seems to have had a smaller effect on autumn pastures, as large portion of autumn pasture area did not show any difference in their degradation trends post and pre-IFAD intervention.
- **Isolated cases of degradation in spring pasture**: The only case were the degradation trend appeared as worsening was in small patches of spring pastures.

Figure 2 – difference in degradation dynamics for the period pre and post IFAD intervention – All-seasons pastures
Source: GMV

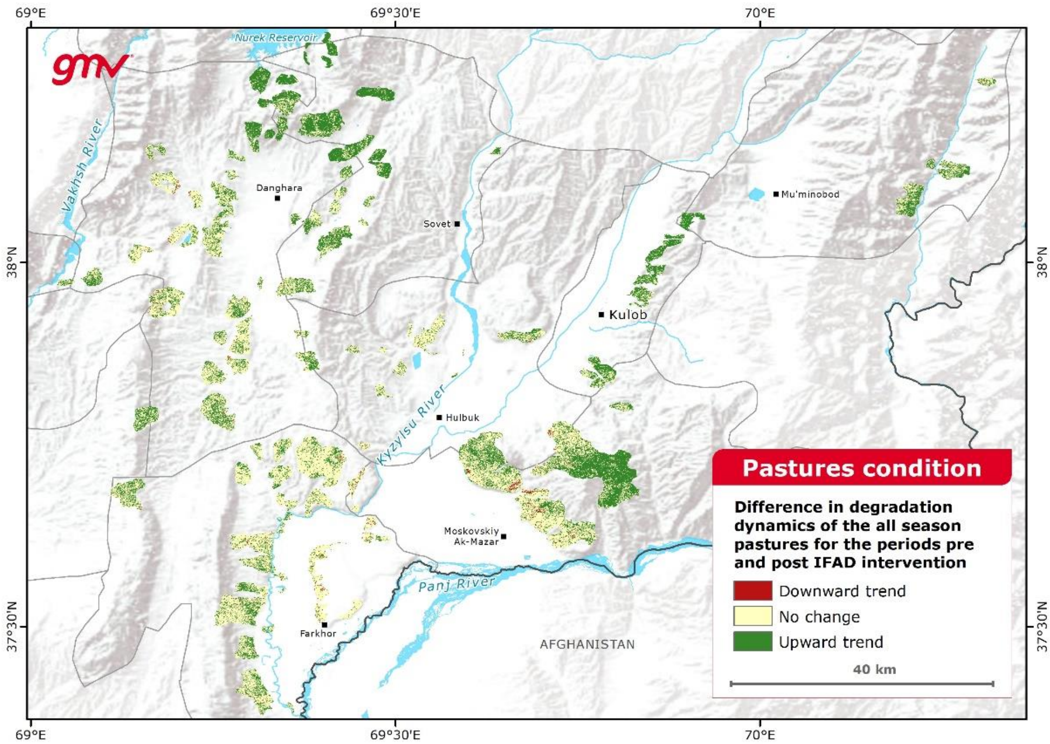

Figure 3 – Difference in degradation dynamics for the period pre and post IFAD intervention – spring pastures
Source: GMV

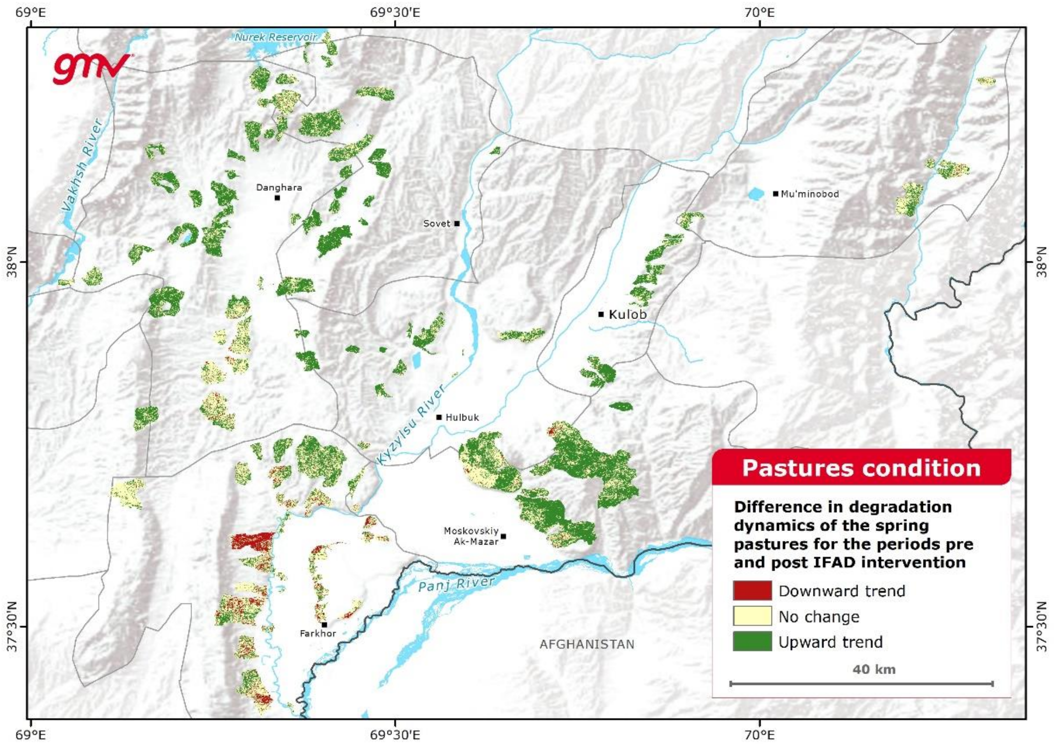

Figure 4 – Difference in degradation dynamics for the period pre and post IFAD intervention – summer pastures
Source: GMV

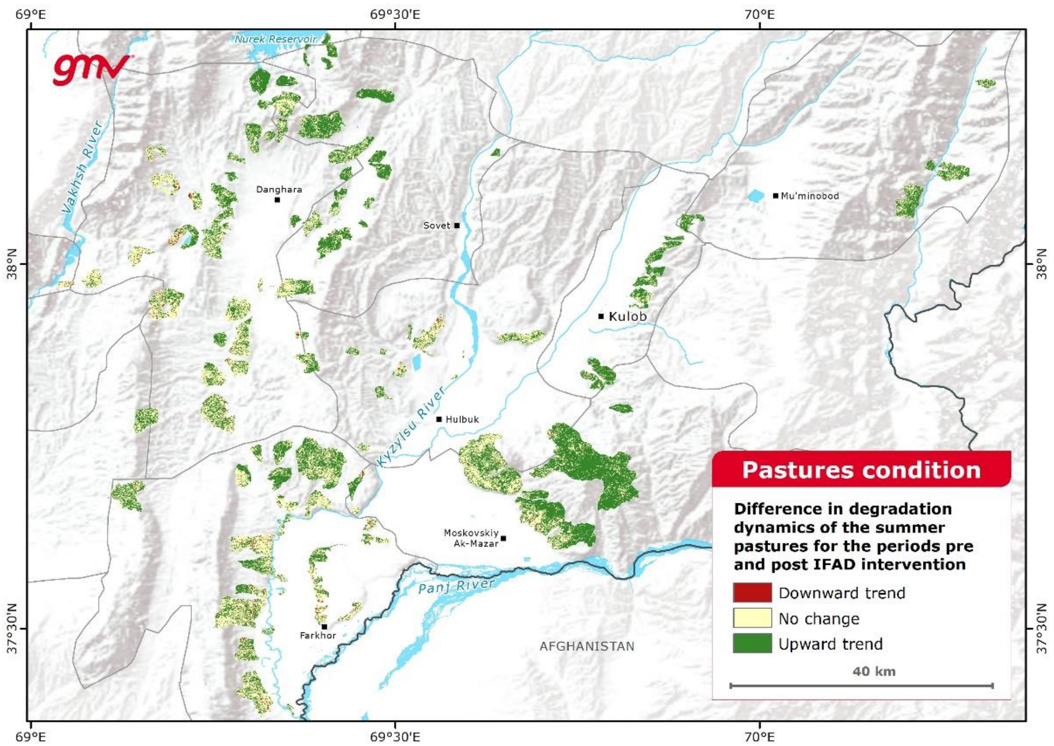

Figure 5 – Difference in degradation dynamics for the period pre and post IFAD intervention – Autumn pastures
Source: GMV

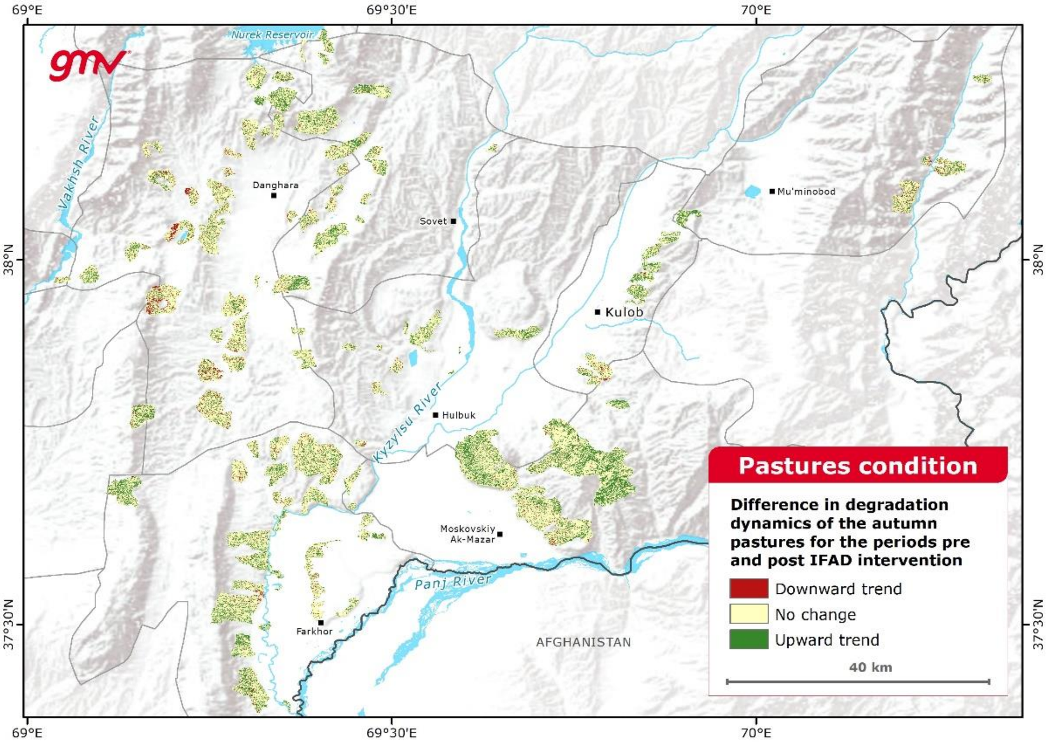

Figure 6 – Difference in degradation dynamics for the period pre and post IFAD intervention – winter pastures
Source: GMV