**Table S1.** List of environmental covariates for digital soil mapping.

| Type of index | Covariate name (abbreviation) | Definition | Reference |
|---|---|---|---|
| Terrain indices | Altitude (DEM) | Height over sea level | |
| | Slope | Gradient of line is changing of elevation in the direction and steepness | |
| | Aspect (ASP) | Direction of the line of the steepest descent | |
| | Curvature | The degree to which a curve deviates from a straight line | [77] |
| | Plan curvature (Plancurv) | Rate of change of aspect along a contour | |
| | Profile curvature (Profcurv) | Rate of change of slope down a slope line | |
| | Convergence | Highlights the convergent areas as channels and divergent areas as ridges. | |
| | Analytical hillshade | Angle between the surface and the incoming light beams | [50] |
| | Channel network | The interpolated channel network base level elevations | [77] |
| | Vertical distance to channel network (VDTCN) | Calculates the vertical distance to a channel network base level | [50] |
| | Topographic roughness (TRI) | Measures terrain ruggedness | |
| | Stream power (SPI) | A measure of the topographic control on the sediment transport (USLE's LS factor) | [78] |
| | Topographic wetness index (TWI) | A measure of the topographic control on soil wetness or the ratio | |
| | Multi-resolution valley bottom flatness index (MRVBF) | Measure of flatness and lowness | [77] |
| | Multi-resolution of ridge top flatness index (MRRTF) | Measure of flatness and lowness | |
| | Topographic position (TPI) | Difference between a cell elevation value and the average elevation of the neighborhood around that cell | [50] |
| | Mass balance (MBI) | Balance between soil mass deposited and eroded | |
| | Wind effect | Dimensionless index indicating areas exposed to wind | [79] |
| | Valley depth | The vertical distance to a channel network base level | |
| | Relative slope position (RSP) | The position of one point relative | [50] |
| | Terrain surface texture (Texure) | The geometrical irregularities present at a surface or the nested-means terrain classification | |
| Remote sensing | Salinity (SI) | $\sqrt{B2 \times B4}$ | |
| | Salinity1 | $B2/B4$ | |
| | Salinity2 | (B2-B4)/(B2+B4) | |
| | Salinity3 | (B3×B4)/B2 | |
| | Salinity4 | (B2×B4)/B3 | [80] |
| | Salinity5 | (B2×B4)/B3 | |
| | Salinity6 | (B4×B8A)/B3 | |
| | Normalized difference salinity (NDSI) | (B4-B8A)/(B4+B8A) | |
| | Salinity Index-T (SI-T) | (B4/B8A)/100 | |
| | (SI1) | $\sqrt{B3^2 + B4^2 + B8A^2}$ | [81] |
| | (SI2) | $\sqrt{B3^2 + B4^2}$ | [82] |
| | Soil moisture monitoring (SMMI) | $\sqrt{B8A^2 + B11^2} / \sqrt{2}$ | |
| | Visible and shortwave drought (VSDI) | 1-(B12+B4-2×B2) | |
| | Normalized difference water (NDWI) | (B8A-B11)/(B8A+B11) | [83] |
| | Redness (RI) | $(B4)^2/(B3)^2$ | |
| | Brightness (BI) | $\sqrt{(B4^2 + B3^2 + B2^2)} / 3$ | |
| | Second brightness (BI2) | $\sqrt{(B4^2 + B3^2 + B8A^2)} / 3$ | |
| | Carbonate (CaI) | $B4/B3$ | [84] |
| | Ferrous (FeI) | B4/SWIR1 | |
| | Clay (ClayI) | SWIR1/SWIR2 | |
| | Saturation (SI) | (B4-B2)/(B4+B2) | |
| | Coloration (CI) | (B4-B3)/(B4+B3) | |
| | Hue (HI) | (2×B4-B2)/(B4+B2) | [83] |
| | Grain size (GSI) | (B4-B2)/(B4+B3+B2) | |
| | Normalized difference (GeoI) | (SWIR1-SWIR2)/(SWIR1+SWIR2) | |
| | Normalized difference (CalcI) | (SWIR1-B3)/(SWIR1+B3) | |
| | Intensity1 | (B3+B4)/2 | [80] |
| | Intensity2 | (B3+B4+B8A)/2 | |
| | Infrared percentage vegetation (IPVI) | B8 /( B8 + B4) | |
| | Moisture stress (MSI) | SWIR1/B8 | |
| | Normalized multiband drought (NMDI) | $\frac{B8A-(B11-B12)}{B8A+(B11+B12)}$ | [51] |
| | Normalized shortwave-infrared difference SM (NSDSI3) | (B11-B12)/(B11+B12) | |
| | Perpendicular drought index 311 (PD311) | | [85] |
| | Perpendicular drought index 322 (PD322) | (B4-B3)/(B4+B3) | |
| | Enhanced vegetation (EVI) | $\frac{2.5 \times (B8A-B4)}{(B8A+6 \times B4-7.5 \times B2+1)}$ | [86] |
| | Normalized difference vegetation index red-edge 1 (NDVIrel) | (B8A-B5)/(B8A+B5) | |

| | | | |
|---|---|---|---|
| | Normalized difference vegetation index red-edge 2 (NDVIre2) | (B8A-B6)/(B5+B6) | |
| | Normalized difference red-edge 1 (NDre1) | (B6-B5)/(B6+B5) | |
| | Normalized difference red-edge 2 (NDre2) | (B7-B5)/(B7+B5) | |
| | Triangular chlorophyll (TCIrel) | $1.2\times(B5-B3)-1.5\times(B4-B3)\times\sqrt{\frac{B5}{B4}}$ | |
| | Transformed vegetation (TVI) | $\sqrt{\left(\frac{B8-B4}{B8+B4}+0.5\right)}\times100$ | |
| | Weighted difference vegetation (WDVI) | B8−(B8/B4)×B4 | |
| | Soil adjusted total vegetation (SATVI) | $\left(\frac{B11-B4}{B11+B4+L}\right)\times(1+L)-\frac{B12}{2}$ L=1 | |
| | Soil adjusted vegetation index (SAVI) | $\frac{(B8-B4)\times(1+L)}{(B8-B4+L)}$ L=0.5 | [87] |
| | Optimized soil-adjusted vegetation (OSAVI) | (B8 –B4)/(B8 + B4 + 0.16) | [88] |
| | Normalized difference vegetation (NDVI) | (B8A-B4)/ (B8A+B4) | [89] |
| | Ratio vegetation (RVI) | (B8/B4) | [90] |
| | Difference vegetation (DVI) | (B8-B4) | |
| | Green-Red vegetation (GRVI) | (B3-B4)/(B3+B4) | |
| | Green normalized difference vegetation (GNDVI) | (B8-B3)/(B8+B3) | [86] |
| | Modified soil adjusted vegetation (MSAVI) | $\frac{2\times B4+1-\sqrt{(2\times B8A+1)^2-8\times(B8A-B4)}}{2}$ | |
| | Land use map | | |
| Parent material | Geology map | | |
| Parent material, topography, soil | Landform map | | [91,92] |
| Groundwater quality parameters | $HCO_3^-$, $Cl^-$, $SO_4^{2-}$, $Na^+$, $Ca^{2+}$, $Mg^{2+}$, EC, pH, SAR, and TDS | | |

**Sentinel 2 Bands:** B2= Blue (492.4 nm), B3= Green (559.8 nm), B4= Red (664.6 nm), B5= Vegetation Red Edge (704.1 nm), B6 = Vegetation Red Edge (740.5 nm), B7= Vegetation Red Edge (782.8 nm), B8=NIR (832.8 nm), B8A= Narrow NIR (864.7 nm), B10=SWIR1 (1373.5 nm), B11= SWIR2 (1613.7 nm).