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1

FishyIPMS

2

Kwaku Peprah Adjei

3 1 First meeting notes

4 Quarto enables you to weave together content and executable code into a finished document. To
5 learn more about Quarto see <https://quarto.org>.

$$\cdot H_t = N_t + \dots + E_t \rightarrow \text{var in covariates}$$

NOTE: survey is designed for lakes that do not change, so you do not change catchment val-

6 1.1 Objectives

- 7 • Fit a population dynamic model (IPMs) with anthropogenic drivers (human driven factors such
8 as climate change, direct exploitation, pollution, biological invasions, sea-use change; Moullec
9 et al., 2021).
- 10 • The IPM should be a mechanistic model (plug and play; Frost et al., 2023; Smallegange et al.,
11 2017). The IPMs should describe how the variables affect population.
- 12 • IPMs should model temporal trends in human characteristics using variables that indicate
13 catchment state of each year and a continuous time series data.
- 14 • Produce prediction maps (of what?)

15 1.2 Covariates to use

- 16 • Easily accessible variables e.g. using remote censored data
- 17 • environmental covariates : type of forestry
build dummy IPMs.

Lots of variables because we also want to do an exploration of all the variables to find out which one sort of -

- Green metrics → influence & pattern.
- Make a lot of assumptions.
- Don't be stuck on IPMs if it does not work out.
→ What should we sample or monitor to answer these questions.
→ spot -

18 2 Example data received

19 The data is explained in Bærum et al. (2021).

20 The following data have been received:

21 2.1 Dataset 1: Individual data for some fish populations

- 22 • Each row = one individual fish

+ open demographic model,
+ integrated pcpn model,

+ spatial model → temporal model.

```

library(readr)

Example1 <- read_delim("Example1.csv", delim = ";", escape_double = FALSE, trim_ws = TRUE)

#explore data
colnames(Example1)
23

24 [1] "Column1"          "klima"           "loknr"           "lpnr"
25 [5] "dato"             "juli"             "periode"         "navn"
26 [9] "kode"              "lenkenr"          "garnnr"          "m_vidde"
27 [13] "dyp1"             "dyp2"             "gj_dyp"          "art"
28 [17] "Lengde"           "vekt"             "k"                "v_gonfri"
29 [21] "kjonn"            "stadium"          "moden"           "moden1"
30 [25] "mage"              "cyst"             "gen"              "lpnr_2"
31 [29] "otr"               "alder_aar"        "otr_1"           "v_skaal"
32 [33] "v_skaalmfisk"     "vekt_diff"        "v_gonader"       "gon_kode"
33 [37] "v_skaal_dryw"      "wetprosent"       "v_glass"          "v_glass_prove"
34 [41] "l_prove"            "v_prove"          "cs137_wet"       "cs137_dry"
35 [45] "filet"              "s_vekting"        "moh"

summary(Example1)
36

37   Column1          klima          loknr          lpnr
38   Min. : 1   Min. :1.000   Min. : 1.00   Min. : 1.0
39   1st Qu.:2123 1st Qu.:2.000  1st Qu.: 7.00  1st Qu.: 64.0
40   Median :3304  Median :2.000  Median :10.00  Median :132.0
41   Mean   :3210  Mean   :2.072  Mean   :10.71  Mean   :182.1
42   3rd Qu.:4387 3rd Qu.:3.000  3rd Qu.:16.00  3rd Qu.:262.0
43   Max.   :5733  Max.   :3.000  Max.   :21.00  Max.   :608.0
44

45   dato          juli          periode        navn
46   Length:3673    Min. :39610   Min. :0.000  Length:3673
47   Class :character 1st Qu.:39708  1st Qu.:1.000  Class :character
48   Mode  :character  Median :39729  Median :1.000  Mode  :character
49                           Mean   :39799  Mean   :1.234
50                           3rd Qu.:39952  3rd Qu.:2.000
51                           Max.   :40001  Max.   :2.000

```

```

52
53      kode          lenkenr        garnnr       m_vidde
54  Length:3673      Min.    : 1.00   Min.    :1.000   Min.    :12.00
55  Class  :character 1st Qu.: 3.00   1st Qu.:1.000   1st Qu.:16.00
56  Mode   :character Median : 9.00   Median :2.000   Median :19.00
57                  Mean   : 10.44   Mean   :1.916   Mean   :20.23
58                  3rd Qu.: 14.00   3rd Qu.:3.000   3rd Qu.:24.00
59                  Max.   :100.00   Max.   :8.000   Max.   :35.00
60                  NA's   :65      NA's   :93      NA's   :107
61      dyp1          dyp2          gj_dyp       art      Lengde
62  Min.    : 0.100   Min.    : 0.500   Min.    : 0.70   Min.    :1     Min.    : 11.0
63  1st Qu.: 1.500   1st Qu.: 2.100   1st Qu.: 1.95   1st Qu.:1     1st Qu.:164.0
64  Median  : 2.300   Median  : 4.000   Median  : 3.25   Median  :1     Median :192.0
65  Mean    : 3.392   Mean    : 5.444   Mean    : 4.42   Mean    :1     Mean   :201.2
66  3rd Qu.: 4.100   3rd Qu.: 6.900   3rd Qu.: 5.25   3rd Qu.:1     3rd Qu.:227.0
67  Max.    :28.600   Max.    :33.500   Max.    :31.05   Max.    :1     Max.   :515.0
68  NA's   :121      NA's   :173      NA's   :184      NA's   :1
69      vekt          k            v_gonfri      kjonn
70  Min.    : 5.3     Min.    : 0.112   Min.    : 8.30   Min.    :1.000
71  1st Qu.: 50.1    1st Qu.: 1.040   1st Qu.: 49.44   1st Qu.:1.000
72  Median  : 76.0    Median  : 1.110   Median  : 83.00   Median  :1.000
73  Mean    : 114.1   Mean    : 2.856   Mean    : 128.63  Mean    :1.474
74  3rd Qu.: 125.8   3rd Qu.: 1.190   3rd Qu.: 149.95  3rd Qu.:2.000
75  Max.    :1323.0   Max.    :5296.769  Max.    :1323.00  Max.    :2.000
76                  NA's   :1825      NA's   :1826
77      stadium        moden        moden1       mage
78  Min.    :1.000    Min.    :0.0000   Min.    :0.0000   Min.    :0.000
79  1st Qu.:1.000    1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:1.000
80  Median  :2.000    Median :0.0000   Median :0.0000   Median :2.000
81  Mean    :2.132    Mean    :0.1982   Mean    :0.2832   Mean    :1.738
82  3rd Qu.:2.000    3rd Qu.:0.0000   3rd Qu.:1.0000   3rd Qu.:2.000
83  Max.    :7.000    Max.    :1.0000   Max.    :1.0000   Max.    :5.000
84  NA's   :1826     NA's   :1826     NA's   :1826     NA's   :1827
85      cyst          gen          lpnr_2       otr
86  Min.    :0.0000   Min.    :0.0000   Min.    : 1.00   Min.    :0.090
87  1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.: 26.00   1st Qu.:0.860

```

```

88 Median :0.0000  Median :0.0000  Median : 50.00  Median :1.060
89 Mean    :0.4158  Mean   :0.0012  Mean   : 69.95  Mean   :1.102
90 3rd Qu.:1.0000 3rd Qu.:0.0000 3rd Qu.:106.00 3rd Qu.:1.290
91 Max.    :3.0000  Max.   :1.0000  Max.   :234.00  Max.   :2.760
92 NA's    :1826    NA's   :1967    NA's   :2432    NA's   :2456
93 alder_aar      otr_1      v_skaal      v_skaalmfisk
94 Min.    : 1.000  Min.   :0.010  Min.   : 2.080  Min.   : 10.00
95 1st Qu.: 4.000 1st Qu.:0.790 1st Qu.: 2.180 1st Qu.: 45.43
96 Median : 5.000  Median :0.990  Median : 7.880  Median : 85.90
97 Mean    : 4.964  Mean   :1.024  Mean   : 6.654  Mean   :127.84
98 3rd Qu.: 6.000 3rd Qu.:1.210 3rd Qu.: 8.050 3rd Qu.:147.30
99 Max.    :12.000  Max.   :2.700  Max.   :28.400  Max.   :1282.00
100 NA's   :2455    NA's   :2456    NA's   :1825    NA's   :1828
101 vekt_diff      v_gonader   gon_kode     v_skaal_dryw
102 Min.    : 0.00  Min.   : 0.432  Min.   :1.000  Min.   : 3.80
103 1st Qu.: 0.00 1st Qu.: 2.980 1st Qu.:1.000 1st Qu.: 12.20
104 Median : 0.00  Median :11.390  Median :1.000  Median : 26.20
105 Mean    : 13.33 Mean   :15.932  Mean   :1.143  Mean   : 36.47
106 3rd Qu.: 0.00 3rd Qu.:23.988 3rd Qu.:1.000 3rd Qu.: 42.27
107 Max.    :929.45 Max.   :139.900 Max.   :2.000  Max.   :330.50
108 NA's   :1825    NA's   :3495    NA's   :3526    NA's   :1830
109 wetprosent    v_glass     v_glass_prove l_prove
110 Min.    :69.52  Min.   :5.755  Min.   : 7.947  Min.   :15.00
111 1st Qu.:75.17 1st Qu.:6.054 1st Qu.:11.837 1st Qu.:59.00
112 Median :76.40  Median :8.500  Median :14.390  Median :60.00
113 Mean    :76.32  Mean   :7.736  Mean   :13.628  Mean   :57.58
114 3rd Qu.:77.70 3rd Qu.:8.611 3rd Qu.:15.020 3rd Qu.:60.00
115 Max.    :81.65  Max.   :8.864  Max.   :17.150  Max.   :66.00
116 NA's   :1826    NA's   :1825    NA's   :1826    NA's   :1826
117 v_prove       cs137_wet   cs137_dry    filet
118 Min.    :1.265  Min.   : 6.43  Min.   : 26.47  Min.   :0.0000
119 1st Qu.:5.587 1st Qu.:33.24 1st Qu.:142.68 1st Qu.:0.0000
120 Median :5.974  Median :67.59  Median :283.90  Median :0.0000
121 Mean    :5.893  Mean   :86.11  Mean   :362.91  Mean   :0.0357
122 3rd Qu.:6.440 3rd Qu.:116.47 3rd Qu.:493.16 3rd Qu.:0.0000
123 Max.    :8.610  Max.   :779.93  Max.   :3726.78 Max.   :1.0000

```

```

124 NA's :1826    NA's :1827    NA's :1827    NA's :1851
125   s_vekting      moh
126   Min. :0.72    Min. : 36.0
127   1st Qu.:1.07  1st Qu.:162.0
128   Median :1.19  Median :205.0
129   Mean   :1.18  Mean   :288.7
130   3rd Qu.:1.30  3rd Qu.:535.0
131   Max.  :2.08  Max.  :800.0
132

```

133 2.1.1 Column names and their meaning

134 *which columns are interesting?*

135 2.2 Dataset 2: Subsample of dataset 1

136 Here the ID represents and individual fish.

```

Example2 <- read_delim("Example2.csv", delim = ";",
                        escape_double = FALSE, trim_ws = TRUE)
colnames(Example2)

```

```

137
138 [1] "LengdeVvekst"  "LengdeValder"  "vekstaar"      "vekstalder"
139 [5] "alder_aar"     "ID"           "tilv_lengde"   "klima"
140 [9] "loknr"         "moh"          "lpnr"         "dato"
141 [13] "aar"          "periode"       "navn"         "alder"
142 [17] "lengde"        "vekt"          "kjonn"        "moden"
143 [21] "moden1"        "tilvekstalder" "tilvekst"     "inst_vekst"
144 [25] "CPUE"          "Temp_mai"      "Temp_juni"    "Temp_juli"
145 [29] "nedbor_mai"    "nedbor_juni"   "nedbor_juli"  "tempratur"
146 [33] "nedbor"         "NaoV"          "Column1"      "_1"
147 [37] "_2"            "_3"           "_4"          "_5"

```

```

summary(Example2)

```

```

148
149 LengdeVvekst  LengdeValder  vekstaar  vekstalder
150 Min.   : 10.00  Min.   : 10.00  Min.   :1998  Min.   :0.000
151 1st Qu.: 35.56  1st Qu.: 35.56  1st Qu.:2004  1st Qu.:1.000
152 Median : 83.05  Median : 83.05  Median :2005  Median :2.000

```

```

153  Mean    : 93.25   Mean    : 93.24   Mean    :2005   Mean    :2.218
154  3rd Qu.:141.08  3rd Qu.:141.08  3rd Qu.:2006  3rd Qu.:3.000
155  Max.    :409.49   Max.    :409.49   Max.    :2008   Max.    :9.000
156
157  alder_aar          ID        tilv_lengde      klima
158  Min.    : 1.000   Min.    : 1.0  Length:4289       Min.    :1.000
159  1st Qu.: 2.000  1st Qu.:219.0  Class  :character  1st Qu.:1.000
160  Median  : 3.000  Median  :445.0   Mode   :character  Median  :2.000
161  Mean    : 3.218   Mean    :443.4           Mean    :2.159
162  3rd Qu.: 4.000  3rd Qu.:670.0           3rd Qu.:3.000
163  Max.    :10.000   Max.    :896.0           Max.    :3.000
164
165  loknr            moh        lptrn       dato
166  Min.    : 1.00   Min.    : 36.0  Min.    : 1.00  Length:4289
167  1st Qu.: 6.00  1st Qu.: 92.0  1st Qu.: 24.00  Class  :character
168  Median  :10.00  Median  :205.0  Median  : 42.00  Mode   :character
169  Mean    :11.38   Mean    :341.7   Mean    : 60.77
170  3rd Qu.:18.00  3rd Qu.:600.0  3rd Qu.: 88.00
171  Max.    :21.00   Max.    :800.0   Max.    :227.00
172
173  aar              periode     navn        alder
174  Min.    :2008   Min.    :0.0000  Length:4289       Min.    : 1.000
175  1st Qu.:2008  1st Qu.:0.0000  Class  :character  1st Qu.: 4.000
176  Median  :2008  Median  :1.0000  Mode   :character  Median  : 5.000
177  Mean    :2008   Mean    :0.6706           Mean    : 5.446
178  3rd Qu.:2008  3rd Qu.:1.0000           3rd Qu.: 7.000
179  Max.    :2008   Max.    :1.0000           Max.    :12.000
180
181  lengde          vekt        kjonn      moden
182  Min.    : 85    Min.    :  8.3  Min.    :1.000  Min.    :0.0000
183  1st Qu.:180   1st Qu.: 62.1  1st Qu.:1.000  1st Qu.:0.0000
184  Median  :215   Median  :107.3  Median :1.000  Median :0.0000
185  Mean    :223   Mean    :154.4  Mean    :1.493  Mean    :0.2414
186  3rd Qu.:259   3rd Qu.:193.5  3rd Qu.:2.000  3rd Qu.:0.0000
187  Max.    :453   Max.    :1030.8  Max.    :2.000  Max.    :1.0000
188  NA's    :10          NA's    :2          NA's    :2

```

```

189      moden1      tilvekstalder      tilvekst      inst_vekst
190      Min.    :0.0000  Length:4289      Min.    : 4.41  Min.    :0.3828
191      1st Qu.:0.0000  Class  :character  1st Qu.: 30.59 1st Qu.:1.0283
192      Median  :0.0000  Mode   :character  Median  : 37.51  Median  :1.0796
193      Mean    :0.2498                   Mean    : 39.02  Mean    :1.0825
194      3rd Qu.:0.0000                   3rd Qu.: 46.00 3rd Qu.:1.2088
195      Max.    :1.0000                   Max.    :151.43  Max.    :2.0314
196      NA's    :2                      NA's    :1
197      CPUE          Temp_mai      Temp_juni      Temp_juli
198      Min.    : 0.6095  Min.    : 3.983  Min.    : 7.65  Min.    :11.51
199      1st Qu.: 1.7000  1st Qu.: 5.803  1st Qu.:10.14  1st Qu.:13.98
200      Median  : 3.8889  Median  : 7.110  Median  :11.55  Median  :14.93
201      Mean    : 4.1464  Mean    : 7.221  Mean    :11.40  Mean    :14.75
202      3rd Qu.: 5.0357  3rd Qu.: 8.510  3rd Qu.:12.45  3rd Qu.:15.96
203      Max.    :16.8889  Max.    :12.343  Max.    :15.78  Max.    :17.49
204
205      nedbor_mai      nedbor_juni      nedbor_juli      tempratur
206      Min.    : 6.20    Min.    : 8.80    Min.    : 12.80  Min.    : 9.412
207      1st Qu.: 48.30   1st Qu.: 44.20   1st Qu.: 54.50  1st Qu.:10.664
208      Median  : 70.90   Median  : 67.80   Median  : 71.60  Median  :11.759
209      Mean    : 64.31    Mean   : 63.13    Mean   : 76.29  Mean    :11.816
210      3rd Qu.: 80.20   3rd Qu.: 75.60   3rd Qu.:101.00 3rd Qu.:12.847
211      Max.    :106.40   Max.   :155.80   Max.   :195.80  Max.    :15.078
212
213      nedbor          NaoV          Column1        _1
214      Min.    :209.4    Min.    :-0.8200   Mode:logical  Mode:logical
215      1st Qu.:315.8    1st Qu.:-0.2000  NA's:4289     NA's:4289
216      Median  :390.3    Median :-0.1100
217      Mean    :383.6    Mean    : 0.2695
218      3rd Qu.:428.7    3rd Qu.: 0.7900
219      Max.    :540.2    Max.    : 1.8500
220
221      _2            _3            _4            _5
222      Min.    : 1.000  Min.    : 668  Length:4289      Min.    : 36.0
223      1st Qu.: 5.000  1st Qu.: 36938 Class  :character  1st Qu.: 60.0
224      Median  :10.000  Median  : 38967 Mode   :character  Median  :205.0

```

```

225   Mean    : 9.529    Mean    : 41208          Mean    : 288.4
226   3rd Qu.: 14.000    3rd Qu.: 40445          3rd Qu.: 535.0
227   Max.    : 18.000    Max.    : 118010         Max.    : 663.0
228   NA's    : 4272      NA's    : 4272          NA's    : 4272

```

229 *Do we link both datasets by their IDs?*

230 NOTE: There is no ID in the first dataset. So do I link them by species or develop a species-specific IPM?

232 2.3 Dataset 3: Catchment collected per lake

- 233 • Each row represents a lake

```

234
235   catchments <- read_csv("NO_all_vars_over_catchments.csv")
236   colnames(catchments)      (summary of which will be interesting).

```

```

235   [1] "vassdragNr"
236   [2] "vatnLnr"
237   [3] "Land principally occupied by agriculture, with significant areas of natural vegetation"
238   [4] "Broad-leaved forest"
239   [5] "Moors and heathland"
240   [6] "Sparsely vegetated areas"
241   [7] "Peat bogs"
242   [8] "Water bodies"
243   [9] "Discontinuous urban fabric"
244   [10] "Non-irrigated arable land"
245   [11] "Coniferous forest"
246   [12] "Transitional woodland-shrub"
247   [13] "Complex cultivation patterns"
248   [14] "Water courses"
249   [15] "Mixed forest"
250   [16] "Industrial or commercial units"
251   [17] "Green urban areas"
252   [18] "Sport and leisure facilities"
253   [19] "Continuous urban fabric"
254   [20] "Road and rail networks and associated land"
255   [21] "Airports"
256   [22] "Pastures"

```

```
257 [23] "Bare rocks"  
258 [24] "Mineral extraction sites"  
259 [25] "Inland marshes"  
260 [26] "Glaciers and perpetual snow"  
261 [27] "Sea and ocean"  
262 [28] "Port areas"  
263 [29] "Natural grasslands"  
264 [30] "Intertidal flats"  
265 [31] "mean_ndsi"  
266 [32] "fractional_snow_cover"  
267 [33] "mean_ndvi"  
268 [34] "total_road_length"  
269 [35] "road_density"  
270 [36] "total_ditch_length"  
271 [37] "ditch_density"  
272 [38] "unbuilt"  
273 [39] "res_built"  
274 [40] "nres_built"  
275 [41] "total_population"  
276 [42] "population_density"  
277 [43] "gHM"
```

```
summary(catchments)
```

```
278  
  
279   vassdragNr          vatnLnr  
280   Length:591           Min.    :     3  
281   Class  :character   1st Qu.:   118  
282   Mode   :character   Median  : 1051  
283                   Mean    : 5047  
284                   3rd Qu.: 2180  
285                   Max.    :209024  
286  
287   Land principally occupied by agriculture, with significant areas of natural vegetation  
288   Min.    : 0.000  
289   1st Qu.: 0.000  
290   Median : 0.000  
291   Mean    : 2.852
```

292 3rd Qu.: 1.955
 293 Max. :85.934
 294
 295 Broad-leaved forest Moors and heathland Sparsely vegetated areas
 296 Min. : 0.000 Min. : 0.000 Min. : 0.00
 297 1st Qu.: 0.000 1st Qu.: 0.000 1st Qu.: 0.00
 298 Median : 2.167 Median : 5.172 Median :14.28
 299 Mean : 17.817 Mean :15.432 Mean :22.90
 300 3rd Qu.: 30.268 3rd Qu.:25.863 3rd Qu.:41.66
 301 Max. :100.000 Max. :99.896 Max. :99.16
 302
 303 Peat bogs Water bodies Discontinuous urban fabric
 304 Min. : 0.0000 Min. : 0.0000 Min. : 0.00
 305 1st Qu.: 0.0000 1st Qu.: 0.2035 1st Qu.: 0.00
 306 Median : 0.9125 Median : 0.8455 Median : 0.00
 307 Mean : 6.6690 Mean : 2.0653 Mean : 1.44
 308 3rd Qu.: 8.5524 3rd Qu.: 2.2132 3rd Qu.: 0.00
 309 Max. :100.0000 Max. :47.2630 Max. :99.91
 310
 311 Non-irrigated arable land Coniferous forest Transitional woodland-shrub
 312 Min. : 0.000 Min. : 0.00 Min. : 0.000
 313 1st Qu.: 0.000 1st Qu.: 0.00 1st Qu.: 0.000
 314 Median : 0.000 Median : 0.00 Median : 0.000
 315 Mean : 3.504 Mean : 20.05 Mean : 2.656
 316 3rd Qu.: 0.000 3rd Qu.: 39.61 3rd Qu.: 0.000
 317 Max. :96.060 Max. :100.00 Max. :57.443
 318
 319 Complex cultivation patterns Water courses Mixed forest
 320 Min. : 0.0000 Min. : 0.0000 Min. : 0.000
 321 1st Qu.: 0.0000 1st Qu.: 0.0000 1st Qu.: 0.000
 322 Median : 0.0000 Median : 0.0000 Median : 0.000
 323 Mean : 0.3231 Mean : 0.1315 Mean : 1.086
 324 3rd Qu.: 0.0000 3rd Qu.: 0.0000 3rd Qu.: 0.000
 325 Max. :36.0527 Max. :16.6498 Max. :45.713
 326
 327 Industrial or commercial units Green urban areas Sport and leisure facilities

328 Min. : 0.00000	Min. : 0.00000	Min. : 0.00000	
329 1st Qu.: 0.00000	1st Qu.: 0.00000	1st Qu.: 0.00000	
330 Median : 0.00000	Median : 0.00000	Median : 0.00000	
331 Mean : 0.09384	Mean : 0.01138	Mean : 0.06379	
332 3rd Qu.: 0.00000	3rd Qu.: 0.00000	3rd Qu.: 0.00000	
333 Max. : 17.58435	Max. : 2.45899	Max. : 9.76409	
334			
335 Continuous urban fabric Road and rail networks and associated land			
336 Min. : 0.00000	Min. : 0.00000		
337 1st Qu.: 0.00000	1st Qu.: 0.00000		
338 Median : 0.00000	Median : 0.00000		
339 Mean : 0.01214	Mean : 0.01468		
340 3rd Qu.: 0.00000	3rd Qu.: 0.00000		
341 Max. : 5.71279	Max. : 8.18734		
342			
343 Airports Pastures Bare rocks			
344 Min. : 0.000000	Min. : 0.000000	Min. : 0.000	
345 1st Qu.: 0.000000	1st Qu.: 0.000000	1st Qu.: 0.000	
346 Median : 0.000000	Median : 0.000000	Median : 0.000	
347 Mean : 0.001873	Mean : 0.007849	Mean : 2.468	
348 3rd Qu.: 0.000000	3rd Qu.: 0.000000	3rd Qu.: 0.000	
349 Max. : 0.599905	Max. : 1.924005	Max. : 53.809	
350			
351 Mineral extraction sites Inland marshes Glaciers and perpetual snow			
352 Min. : 0.00000	Min. : 0.000000	Min. : 0.0000	
353 1st Qu.: 0.00000	1st Qu.: 0.000000	1st Qu.: 0.0000	
354 Median : 0.00000	Median : 0.000000	Median : 0.0000	
355 Mean : 0.04256	Mean : 0.005025	Mean : 0.0442	
356 3rd Qu.: 0.00000	3rd Qu.: 0.000000	3rd Qu.: 0.0000	
357 Max. : 19.09487	Max. : 2.969928	Max. : 8.9945	
358			
359 Sea and ocean Port areas Natural grasslands Intertidal flats			
360 Min. : 0.0000	Min. : 0.000000	Min. : 0.000000	Min. : 0.000e+00
361 1st Qu.: 0.0000	1st Qu.: 0.000000	1st Qu.: 0.000000	1st Qu.: 0.000e+00
362 Median : 0.0000	Median : 0.000000	Median : 0.000000	Median : 0.000e+00
363 Mean : 0.3005	Mean : 0.002194	Mean : 0.001686	Mean : 1.552e-05

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364 3rd Qu.: 0.0000 3rd Qu.:0.000000 3rd Qu.:0.000000 3rd Qu.:0.000e+00
365 Max. :71.5460 Max. :0.648935 Max. :0.711776 Max. :9.173e-03
366
367   mean_ndsi      fractional_snow_cover    mean_ndvi      total_road_length
368 Min. :-0.2026    Min. :0.0000    Min. :0.1183    Min. : 0
369 1st Qu.: 0.3938  1st Qu.:0.4721  1st Qu.:0.5831  1st Qu.: 0
370 Median : 0.5460  Median :0.9350  Median :0.6757  Median : 4161
371 Mean   : 0.5013  Mean   :0.7263  Mean   :0.6545  Mean   : 20204
372 3rd Qu.: 0.6431  3rd Qu.:0.9998  3rd Qu.:0.7545  3rd Qu.: 19618
373 Max.  : 0.7740  Max.  :1.0000  Max.  :0.8530  Max.  :256730
374 NA's   :4
375   road_density      total_ditch_length ditch_density      unbuilt
376 Min. :0.0000000  Min. : 0.0  Min. :0.000e+00  Min. :0.1520
377 1st Qu.:0.0000000 1st Qu.: 0.0  1st Qu.:0.000e+00  1st Qu.:0.9974
378 Median :0.0004313  Median : 151.2 Median :1.621e-05 Median :0.9998
379 Mean   :0.0012442  Mean   : 6761.6 Mean   :2.667e-04 Mean   :0.9869
380 3rd Qu.:0.0016803  3rd Qu.: 4520.9 3rd Qu.:3.100e-04 3rd Qu.:1.0000
381 Max.  :0.0229385  Max.  :156650.1 Max.  :4.358e-03 Max.  :1.0136
382
383   res_built      nres_built      total_population population_density
384 Min. :0.000000  Min. :0.0000000  Min. : 0.00  Min. : 0.0000
385 1st Qu.:0.000000 1st Qu.:0.0000000  1st Qu.: 0.00  1st Qu.: 0.0000
386 Median :0.000056  Median :0.0000000  Median : 1.13  Median : 0.0537
387 Mean   :0.011244  Mean   :0.0018676  Mean   : 516.91 Mean   : 35.9188
388 3rd Qu.:0.002136  3rd Qu.:0.0002885  3rd Qu.: 42.02 3rd Qu.: 3.6931
389 Max.  :0.739137  Max.  :0.2763020  Max.  :35542.86 Max.  :3069.6211
390
391 gHM
392 Min. :0.01147
393 1st Qu.:0.05810
394 Median :0.09409
395 Mean   :0.17734
396 3rd Qu.:0.25972
397 Max.  :0.75534
398
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