river_extraction_monitoring

April 25, 2022

1 UNDP Development Minerals 2 Illegal River Extraction Monitoring

Objective 5: Investigate the potential of utilizing remote sensing (RS) and earth observation platforms (EO) to monitor Development Minerals extraction sites. The activity will utilise the Digital Earth Platform and it's data pipelines to implement a monitoring methodology for detection of changes in the immediate environment of identified extraction sites, and scale up monitoring to a national scale in a phased manner. A unified notebook based on Digtal Earth Pacific infrastructure will be developed and tested using the open data sources identified above, and various processes such NVDI, Water Index, Turbidity Index, Rader Vegetation Index among others will be tested, merged and extrapolated to a create a map product that best demonstrates changes to the waterways and it's immediate environment due to river extraction. This product will be able to generate impacts maps from 2016 onwards, and previous extraction sites of aggregates will be used as benchmarks and validation testing.

Vectors: **Vegetation Change Detection**: Normalised Difference Vegetation Index (NDVI), Agriculture **River/Waterways Change Detection**: Normalised Difference Water Index (NDWI) **Turbidity/Sediment Index**: Normalised Difference Turbidity Index (NDTI)

Indicies: **NDVI**: (NIR - RED) / (NIR + RED), (B08 - B04) / (B08 + B04) **NDWI**: (GREEN - NIR) / (GREEN + NIR) >= 0.3 - Water, < 0.3 - Non-water, (B8A - B11) / (B8A + B11) **NDTI**: (RED - GREEN) / (RED + GREEN) , (B04 - B03) / (B04 + BO3) **Agriculture**: B11, B08, B02 (SWIR16, NIR, BLUE)

[1]:
```
!pip install -q leafmap
!pip install -q cmocean
```

[ ]:
```
import geopandas as gpd
import matplotlib.pyplot as plt
import leafmap
import dask
from dask_gateway import GatewayCluster
from pystac_client import Client
import planetary_computer as pc
import stackstac
import numpy as np
import xarray as xr
import xrspatial.multispectral as ms
```

```
import cmocean
```

1.0.1 Area and Time Of Interest

[2]:
```
local =  gpd.read_file('fiji_river_nakavu.geojson')
time_range = '2021-01-01/2022-12-31'

#AOI Variables
area_of_interest = local.geometry[0]
bbox = local.total_bounds
local.explore()
```

[2]:
```
<folium.folium.Map at 0x7f910581c670>
```

1.0.2 Setup Dask Cluster

[4]:
```
cluster = GatewayCluster()  # Creates the Dask Scheduler. Might take a minute.
client = cluster.get_client()
cluster.adapt(minimum=4, maximum=100)
print(cluster.dashboard_link)
```

```
https://pccompute.westeurope.cloudapp.azure.com/compute/services/dask-
gateway/clusters/prod.2411bd79cb03461f80456b8f8ecae938/status
```

1.0.3 Request Imageries (STAC)

[5]:
```
catalog = Client.open("https://planetarycomputer.microsoft.com/api/stac/v1")
search = catalog.search(
    collections=["sentinel-2-l2a"],
    intersects=area_of_interest,
    datetime=time_range,
    limit=100,
    query={"eo:cloud_cover": {"lt": 10}},
)
items = list(search.get_items())
for item in items:
    print(f"{item.id}: {item.datetime}")
print(f"{len(items)} Images Returned")
```

```
S2B_MSIL2A_20220413T221939_R029_T60KXE_20220414T154434: 2022-04-13
22:19:39.024000+00:00
S2A_MSIL2A_20220411T223011_R072_T60KXE_20220412T175923: 2022-04-11
22:30:11.024000+00:00
S2B_MSIL2A_20220403T221939_R029_T60KXE_20220404T081228: 2022-04-03
22:19:39.024000+00:00
S2B_MSIL2A_20220215T223009_R072_T60KXE_20220223T201900: 2022-02-15
22:30:09.024000+00:00
```

```
S2A_MSIL2A_20220210T223011_R072_T60KXE_20220221T130112: 2022-02-10
22:30:11.024000+00:00
S2B_MSIL2A_20211114T221939_R029_T60KXE_20211115T065912: 2021-11-14
22:19:39.024000+00:00
S2A_MSIL2A_20210722T221941_R029_T60KXE_20210723T073931: 2021-07-22
22:19:41.024000+00:00
S2B_MSIL2A_20210720T223009_R072_T60KXE_20210721T084527: 2021-07-20
22:30:09.024000+00:00
S2B_MSIL2A_20210717T221939_R029_T60KXE_20210718T061911: 2021-07-17
22:19:39.024000+00:00
S2B_MSIL2A_20210707T221939_R029_T60KXE_20210708T143448: 2021-07-07
22:19:39.024000+00:00
S2B_MSIL2A_20210617T221939_R029_T60KXE_20210618T131432: 2021-06-17
22:19:39.024000+00:00
S2A_MSIL2A_20210516T223011_R072_T60KXE_20210518T065942: 2021-05-16
22:30:11.024000+00:00
S2A_MSIL2A_20210413T221931_R029_T60KXE_20210414T153143: 2021-04-13
22:19:31.024000+00:00
13 Images Returned
```

1.0.4 Sign Images

[6]:
```
items = list(search.get_items())
items = [pc.sign(item).to_dict() for item in items]
```

1.0.5 Stack Images Into Data (xarray)

[7]:
```
data = (
        stackstac.stack(items,
                        bounds_latlon=bbox,
                        assets=["B04", "B03", "B02", "B08", "B11"],  # red,␣
 ↪green, blue, nir, swir16
                        chunksize=8192,
                        resolution=10
                       )
        .where(lambda x: x > 0, other=np.nan)  # sentinel-2 uses 0 as nodata
        .assign_coords(
            band=lambda x: x.common_name.rename("band"), # use common names
            time=lambda x: x.time.dt.round("D") #D, MS,
        )
       )
data
```

[7]:
```
<xarray.DataArray 'stackstac-7212d820a37129736e9a7343c39879dd' (time: 13,
                                                                band: 5,
                                                                y: 176, x: 246)>
dask.array<where, shape=(13, 5, 176, 246), dtype=float64, chunksize=(1, 1, 176,
```

```
246), chunktype=numpy.ndarray>
Coordinates: (12/44)
  * time                                    (time) datetime64[ns] 2021-04-14…
    id                                      (time) <U54 'S2A_MSIL2A_20210413…
  * band                                    (band) <U6 'red' … 'swir16'
  * x                                       (x) float64 6.157e+05 … 6.182e+05
  * y                                       (y) float64 7.99e+06 … 7.988e+06
    s2:water_percentage                     (time) float64 89.21 75.43 … 88.3
    …                                       …
    proj:bbox                               object {600000.0, 7890220.0, 800…
    gsd                                     (band) int64 10 10 10 10 20
    common_name                             (band) <U6 'red' … 'swir16'
    center_wavelength                       (band) float64 0.665 0.56 … 1.61
    full_width_half_max                     (band) float64 0.038 … 0.143
    epsg                                    int64 32760
Attributes:
    spec:         RasterSpec(epsg=32760, bounds=(615700, 7987760, 618160, 7989…
    crs:          epsg:32760
    transform:    | 10.00, 0.00, 615700.00|\n| 0.00,-10.00, 7989520.00|\n| 0.0…
    resolution:   10
```

1.0.6 Define Bands

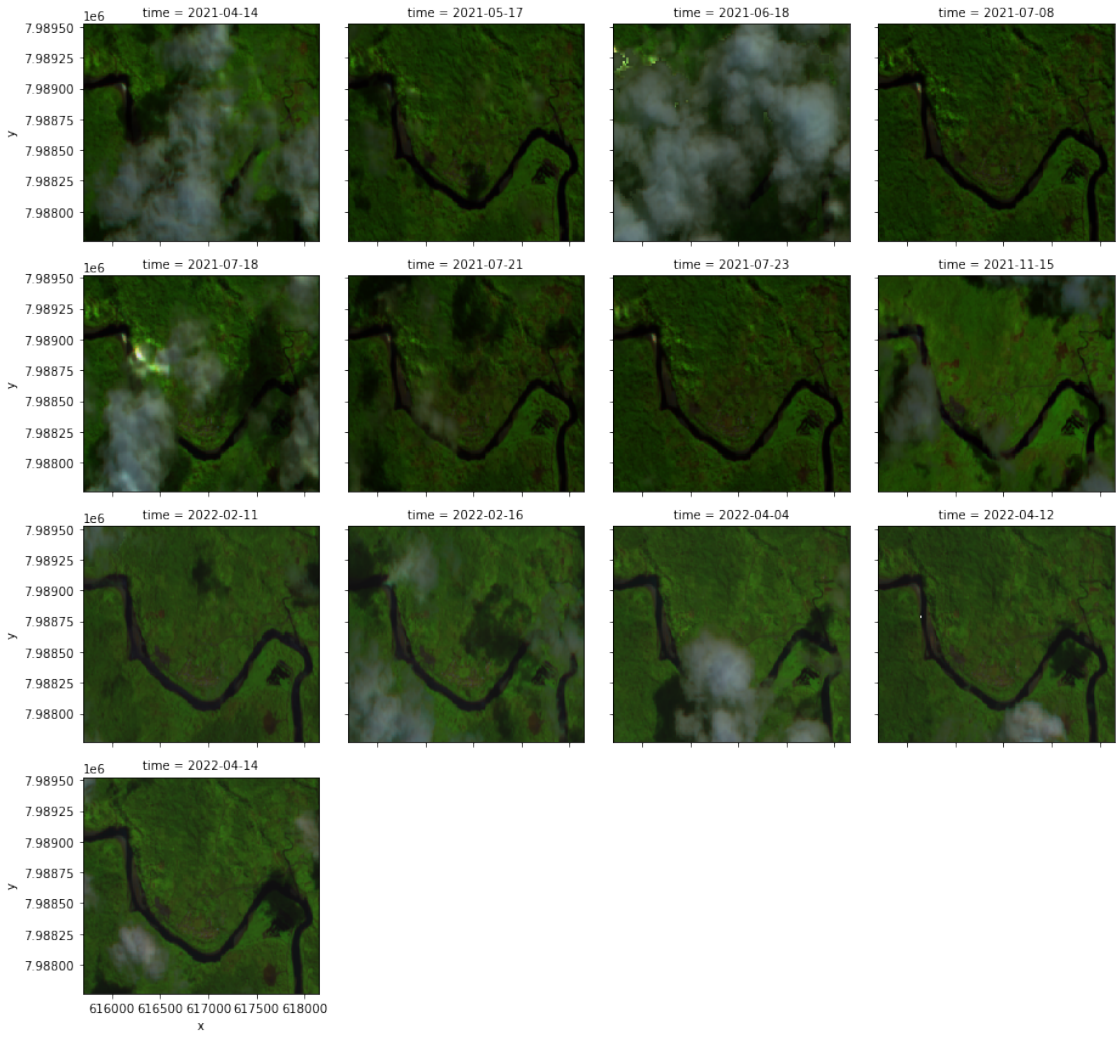
[8]:
```
red = data.sel(band="red")
blue = data.sel(band="blue")
green = data.sel(band="green")
nir = data.sel(band="nir")
swir = data.sel(band="swir16")
```

1.0.7 Vector: Agriculture Band Composite

[9]:
```
vegetation = data.sel(band=["swir16", "nir", "blue"])
```

[10]:
```
vegetation.plot.imshow(x="x", y="y", col="time", col_wrap=4, cmap="viridis")#.
 ↪compute()
```

[10]:
```
<xarray.plot.facetgrid.FacetGrid at 0x7ff5a0c9aeb0>
```

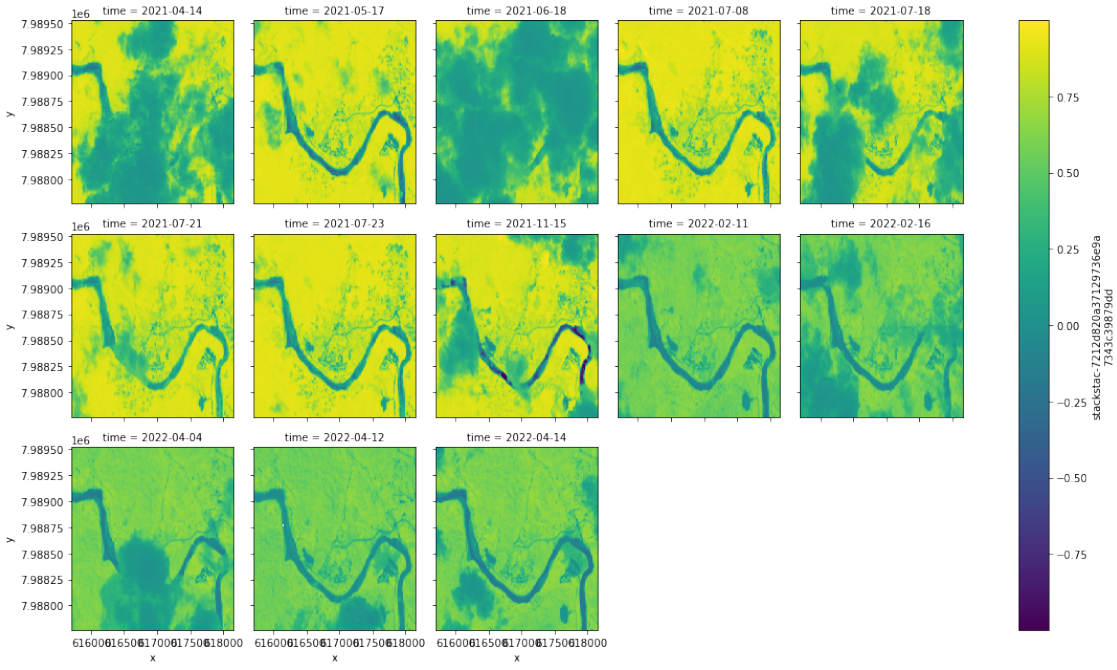


1.0.8 Vector: NDVI (Vegetation Index)

[11]:
```
ndvi = ((nir - red) / (red + nir)).compute()
```

[12]:
```
ndvi.plot.imshow(x="x", y="y", col="time", col_wrap=5, cmap="viridis")
```

[12]:
```
<xarray.plot.facetgrid.FacetGrid at 0x7ff5c5df2610>
```



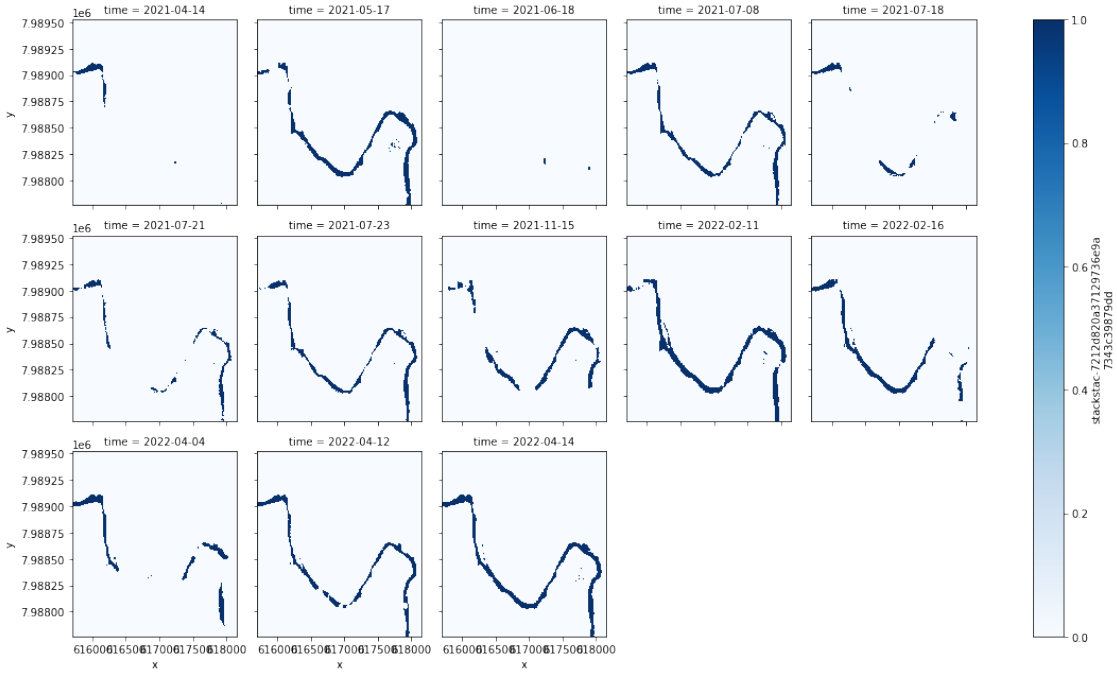
1.0.9 Vector: NDWI (Water Index)

[13]:
```
ndwi = ((green - nir) / (green + nir)).compute()
```

[14]:
```
#remove values less then 0.3
ndwi = ndwi >= 0.0
```

[15]:
```
ndwi.plot.imshow(x="x", y="y", col="time", col_wrap=5, cmap="Blues")
```

[15]: <xarray.plot.facetgrid.FacetGrid at 0x7ff51f5f6e80>

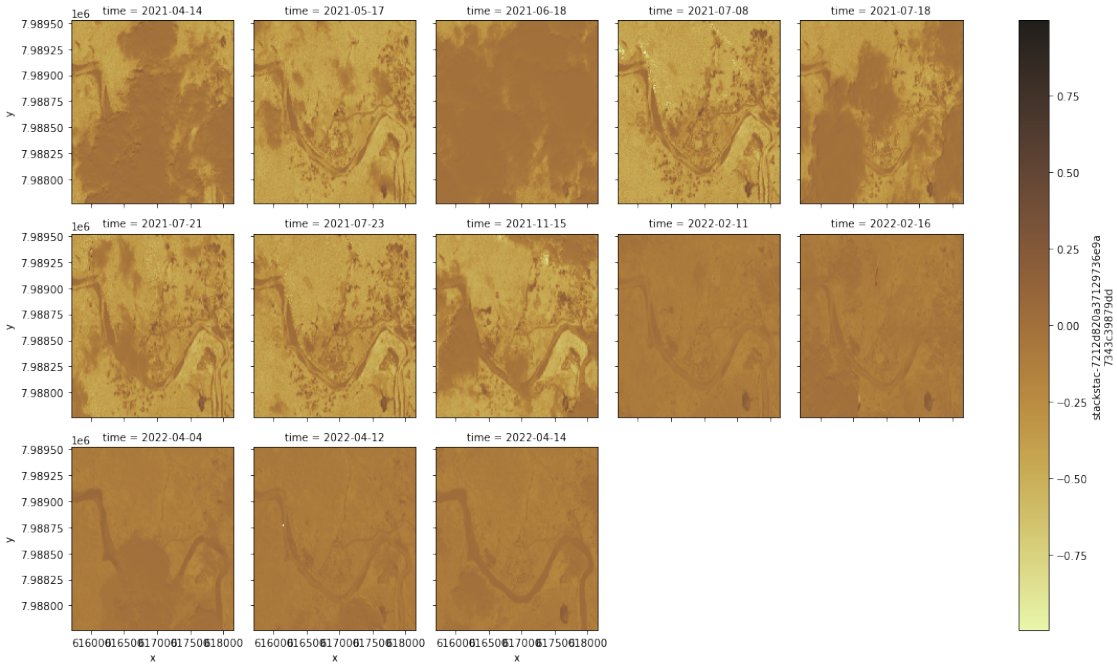


1.0.10 Vector: NDTI (Turbidity Index)

[16]:
```
ndti =  ((red - green) / (red + green)).compute()
```

[17]:
```
#ndti = ndti >= 0.5
ndti.plot.imshow(x="x", y="y", col="time", col_wrap=5, cmap=cmocean.cm.turbid)
```

[17]: <xarray.plot.facetgrid.FacetGrid at 0x7ff51ef8da60>



1.0.11 Change Detection Threshold Definition

Identification of AOI and DateTime of Extraction

[18]:
```
ndvi_change_percent = 0.45
ndwi_change_percent = 0.35
ndti_change_percent = 0.70
vegetation_change_percent = 0.25
```

[19]:
```
#TO BE IMPLEMENTED:
#Calculating and aligning thresholds of the 4 vectors
#Assigning relevance weigthing to each threshold
```

1.0.12 Validation

[20]:
```
#Overlaying and verifing previous instances of licenced extraction area and␣
↪date for Rewa and Navua (data provided by Min.Lands)
```

[ ]:
```

```