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How to Make Multi-Sheet Map Sets Accessible Online

Keywords: processing map sets, cataloging map sets, georeferencing, mosaic map

Summary: Many map libraries are scanning multi-sheets of maps published at the same scale and size covering a country or a region. When these maps are scanned and georeferenced, one challenge map catalogers are facing is how to catalog the different expressions of the same map in their cataloging system. Another challenge is how to make these multi-sheet maps accessible to their users. This paper describes the workflow developed recently by the author addressing the issues related to cataloging digital map sets and providing access to different products of the same map to the users.

Introduction

Many map libraries have large collections of muti-sheet maps, and they have developed different workflows to catalog, digitize and make these maps accessible to their users. When the multi-sheet maps are digitized, georeferenced, and mosaiced, the next question is how to catalog them. Each new product is the expression of the same map. If we catalog them as individual products, then we must create a few new catalog records. However, I recently developed a workflow to process multi-sheet maps that would allow us to convert paper to digital maps and then automatically georeference them, catalog all expressions of the same map in one catalog record, and upload all products of the multi-sheet maps on our Portal under one record.

In this paper I will explain each step of the process so that libraries who are thinking of digitizing and making their multi-sheet maps accessible to their users will know what steps are involved in adopting our workflow. This new workflow allows our users to view all sheets of multi-sheet maps as individual map sheets and download them with or without georeferenced information, but also view them as a mosaic map that combines all sheets together. The same mosaic map can be added to any GIS software packages that can open WMTS or XYZ services.

Scanning workflow and auto georeferencing multi-sheet maps

With all the multi-sheet maps that we plan to automatically georeference using the Quad-G+ software (The software can be download from the Department of Geography at the University of Wisconsin – Madison https://geography.wisc.edu/quad-g/), we follow a specific workflow. Before we scan the map sheets, we create a spreadsheet (Figure 1) with each map sheet number, map sheet name, and the latitude and longitude values of Northeast and Southwest corners of the map sheet. When we scan the map, we use the map sheet name as the file name. After all the map sheets are scanned, then we add the scanned image file name, Spatial Reference System (SRS) information, scale, as well as the number of rows and columns marked on the map sheet.

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We use the spreadsheet file to automatically georeference all the scanned map sets. The Quad-G+ software is relatively easy to use, and you will find documentation[1] on the software from the software download site.

FileName	MapsheetName	MapName	SRS	North	West	East	South	Scale	Rows	Cols
NC_43-11.tif	NC_43-11	Alleppey	Indian1960.wkt	10	75	76.5	9	250000	5	7
NC_43-12.tif	NC_43-12	Rajapālaiyam	Indian1960.wkt	10	76.5	78	9	250000	5	7
NC_43-16.tif	NC_43-16	Trivandrum	Indian1960.wkt	9	76.5	78	8	250000	5	7
NC_43-3.tif	NC_43-3	Calicut	Indian1960.wkt	12	75	76.5	11	250000	5	7
NC_43-4.tif	NC_43-4	Erode	Indian1960.wkt	12	76.5	78	11	250000	5	7
NC_43-7.tif	NC_43-7	Coimbatore	Indian1960.wkt	11	75.5	77	10	250000	5	7
NC_43-8.tif	NC_43-8	Dindigul	Indian1960.wkt	11	77	78.5	10	250000	5	7
NC_44-1.tif	NC_44-1	Salem	Indian1960.wkt	12	78	79.5	11	250000	5	7

Figure 1: Spreadsheet for automatically georeferencing a scanned map sheet

Creating an index map and clipping the map collars

After all the map sheets are georeferenced, then we use Esri's ArcGIS software to mosaic all the georeferenced maps. The mosaiced georeferenced maps will create three different files: boundary, footprint, and image. After a mosaic file is created, we look at the full bounding box extent of the mosaiced map and create four points using the latitude and longitude of Northeast, Southeast, Northwest, and Southwest, then draw a rectangle connecting these four points. We make sure that the rectangle boundary is snapping properly to the corner points. Once the rectangle is drawn, then we count how many map sheets are there on horizontal rows and vertical columns. We use the Fishnet tool (Figure 2) in Esri's ArcGIS software to create a grid based on the number of rows and columns we counted earlier. We make sure to use the Template Extent as the rectangle we created, and enter the number of rows and columns based on how many map sheets are organized in rows and columns in the mosaiced map.

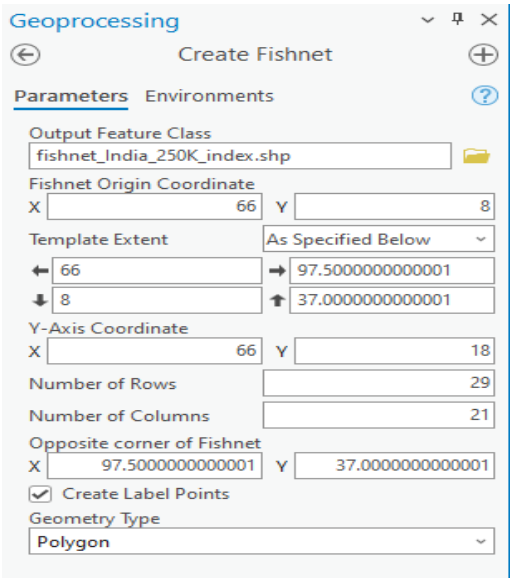

Figure 2: The tool used to create a bounding box for each map sheet.

[1] https://geography.wisc.edu/files/quad-g/Quad-G+_Manual_Ver1.1.pdf

We then export the table of Footprint (Figure 3) and use the CenterX and CenterY columns to create points.

mosaic: Footprint

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

	OBJECTID *	Shape *	Raster	Name	MinPS *	MaxPS *	LowPS *	HighPS *	Category	Tag	GroupName	ProductName	CenterX *	CenterY *	ZOrder
1	1	Polygon	Raster	NC-43-11	0	0.001992	0.000144	0.000577	Primary	Dataset			75.75	9.5	<Null>
2	2	Polygon	Raster	NC-43-12	0	0.001992	0.000144	0.000576	Primary	Dataset			77.25	9.5	<Null>
3	3	Polygon	Raster	NC-43-16	0	0.001992	0.000144	0.000576	Primary	Dataset			77.25	8.5	<Null>
4	4	Polygon	Raster	NC-43-3	0	0.001992	0.000145	0.000581	Primary	Dataset			75.75	11.5	<Null>
5	5	Polygon	Raster	NC-43-4	0	0.001992	0.000145	0.00058	Primary	Dataset			77.25	11.5	<Null>
6	6	Polygon	Raster	NC-43-7	0	0.001992	0.000145	0.000578	Primary	Dataset			76.25	10.5	<Null>
7	7	Polygon	Raster	NC-43-8	0	0.001992	0.000145	0.000579	Primary	Dataset			77.75	10.5	<Null>
8	8	Polygon	Raster	NC-44-1	0	0.001992	0.000145	0.00058	Primary	Dataset			78.75	11.5	<Null>

Figure 3: Mosaic map footprint table

Each Footprint point has a map sheet name. Once the Fishnet grid is created, we use the spatial join tool in the ArcGIS software and join the Footprint points data to the Fishnet grid data. This will create new data that will have a rectangle that matches the actual bounding box and name of each map sheet. We separate each grid using a tool we developed by combining a few ArcGIS tools, and then use the batch raster clipping tool to clip all the map collars from the georeferenced map sheets. This will allow us to create a mosaic map without any collars.

How three different expressions of the same map are cataloged in our system

The map set we have scanned has created three different products: scanned map, georeferenced map with a map collar, and mosaic map without a map collar. It is always a challenge to catalog a map that is converted into different products. Each product of the same map could be cataloged separately. However, the main goal of cataloging maps is so a user can find all the different products of the map easily, and if possible, find the same map in different products or expressions together in one catalog record. This will not only help the user to find all the maps in one catalog record, but also give the option to pick which format the user wants to view or download. We create one catalog record for all three different expressions of the same map. We think this is the best way to allow the user to find all expressions of the same map accessible to the user from one catalog record. In order to catalog all map sheets as one map, we take the latitude and longitude values of the northeast and southwest corners of the mosaic map, then enter that value in the MARC[2] 034 and 255 fields as the bounding box extent (Figure 4). We use the map sheet number and the name of the map sheet that are in the spreadsheet we created earlier to automatically georeference the scanned maps and reformat the map sheet number and name with proper MARC tags, then paste them on the MARC 505 field (Figure 5) in our catalog record. Once the catalog record is created for the map set, we upload the files to our digital repository called Figgy. Figgy is a digital repository that allows our library to ingest, build and publish digital objects.

[2] MARC is the acronym for MAchine-Readable Cataloging

034 1	a| a b| 250000 d| 066.000000 e| 096.000000 f| 37.000000 g| 08.000000
035	a| (OCoLC)on1340447859
040	a| NjP b| eng e| rda c| NjP
043	a| a-ii--- a| a-pk---
050 4	a| G7651 s250 b| .A7M3
052	a| 7650
110 1	a| United States. b| Army Map Service, e| cartographer, e| issuing body.
245 1 0	a| India and Pakistan 1:250,000 / c| prepared by the Army Map Service, Corps of Engineers, U.S. Army.
246 3 0	a| India and Pakistan
246 3 3	i| Standard map series designation: a| Series U502
250	a| Edition 1-AMS ; 2-AMS
255	a| 1:250,000 b| transverse Mercator projection c| (E 66°00′00″--E 96°00′00″/N 37°00′00″--N 8°00′00″).

Figure 4: Catalog record showing MARC fields 034 and 255

505 0 g| NC 43-3. t| Calicut -- g| NC 43-4. t| Erode -- g| NC 43-7. t| Coimbatore -- g| NC 43-8. t| Dindigul -- g| NC 43-11. t| Alleppey -- g| NC 43-12. t| Rajapālaiyam -- g| NC 43-16. t| Trivandrum -- g| NC 44-1. t| Salem -- g| NC 44-5. t| Tiruchirāppalli -- g| NC 44-9. t| Madura -- g| NC 44-13. t| Tuticorin -- g| ND 43-2. t| Belgaum -- g| ND 43-3. t| Hubli -- g| ND 43-4. t| Bellary -- g| ND 43-6. t| Kārwār -- g| ND 43-7. t| Dāvangere -- g| ND 43-8. t| Anantapur -- g| ND 43-11. t| Shimoga -- g| ND 43-12. t| Tumkūr -- g| ND 43-15. t| Mangalore -- g| ND 43-16. t| Mysore -- g| ND 44-1. t| Kurnool -- g| ND 44-2. t| Chīrāla -- g| ND 44-3. t| Divi Point -- g| ND 44-5. t| Cuddapah -- g| ND 44-6. t| Nellore -- g| ND 44-9. t| Kolār -- g| ND 44-10. t| Madras -- g| ND 44-13. t| Bangalore -- g| ND 44-14. t| Conjeeveram -- g| NE 43-1. t| Kalyān -- g| NE 43-2. t| Ahmadnagar -- g| NE 43-3. t| Aurangābād -- g| NE 43-4. t| Nander -- g| NE 43-5. t| Bombay -- g| NE 43-6. t| Poona -- g| NE 43-7. t| Bārsi -- g| NE 43-8. t| Lātūr -- g| NE 43-9. t| Khed -- g| NE 43-10. t| Sātāra -- g| NE 43-11. t| Sholāpur -- g| NE 43-12. t| Gulbarga -- g| NE 43-13. t| Ratnāgiri -- g| NE 43-14. t| Kolhāpur -- g| NE 43-15. t| Bijāpur -- g| NE 43-16. t| Raichūr -- g| NE 44-1. t| Chānda -- g| NE 44-2. t| Sirpur -- g| NE 44-3. t| Jagdalpur -- g| NE 44-4. t| Bhāwanipatna -- g| NE 44-5. t| Nizāmābād -- g| NE 44-6. t| Chinnūr -- g| NE 44-7. t| Malakanagiri -- g| NE 44-8. t| Vizianagram -- g| NE 44-9. t| Hyderābād -- g| NE 44-10. t| Yellandlapād -- g| NE 44-11. t| Sāmalkot -- g| NE 44-12. t| Visākhāpatnam -- g| NE 44-13. t| Wanparti -- g| NE 44-14. t| Vijayavada -- g| NE 44-15. t| Cocanāda -- g| NE 45-1. t| Berhampur -- g| NE 45-2. t| Purī -- g| NE 45-5. t| Parlākimidi -- g| NF 42-2. t| Lakhpat -- g| NF 42-3. t| Bhuj -- g| NF 42-4. t| Rādhanpur -- g| NF 42-7. t| Jamnagar -- g| NF 42-8. t| Rājkot -- g| NF 42-11. t| Porbandar.

Figure 5: Catalog record showing MARC field 505

How we upload three expressions of the same map in our digital repository

We have developed a workflow to upload the scanned, georeferenced maps with or without collars together into Figgy, our digital repository. To upload all three expressions of the same map sheets together, first we need to create the main folder. The name of this main folder should be the MMS-ID (Figure 6) that was generated when we cataloged the map set in our main cataloging system. Under this main folder, we create a subfolder for each map sheet (the name of each subfolder should be the same as the map sheet name) and under each map sheet folder there is another subfolder called Raster. All the scanned maps are saved directly on the main map sheet name subfolder, and georeferenced files with and without map collars are saved in the Raster folder. We differentiate the georeferenced maps with and without map collars by adding "*cropped*" at the end of the file name for those georeferenced maps that do not have map collars.

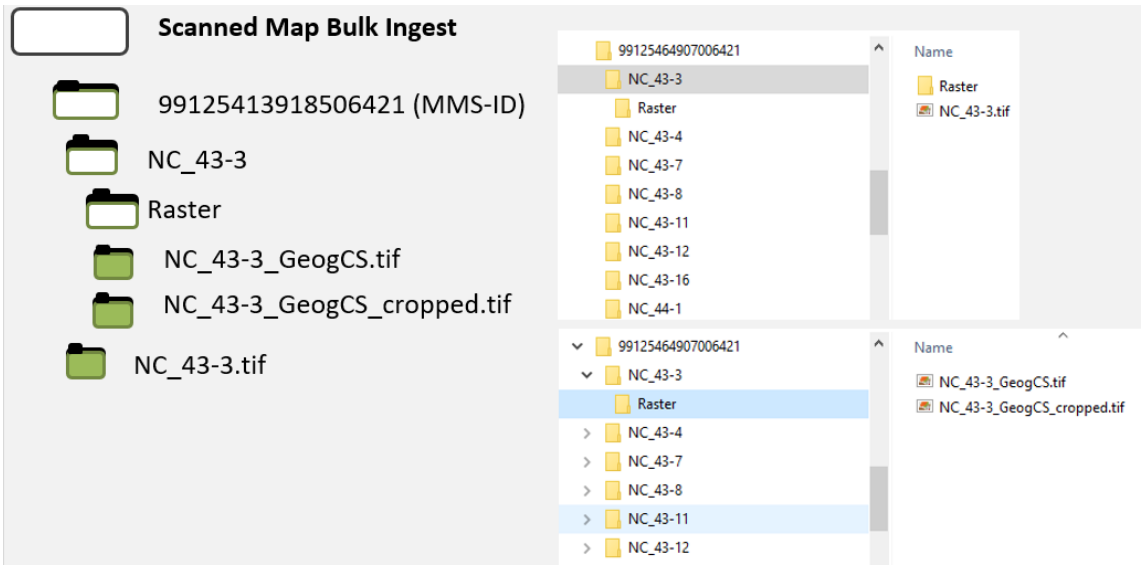

Figure 6: The folder structure of a map set for bulk upload

Once each map sheet is saved in the respective folders, then we open the Figgy site and select the Raster Resource's Bulk Ingest (Figure 7) to upload the digital maps. In the source metadata ID field in Figgy, we enter the same MMS-ID that was created when the map was cataloged in our main cataloging system. Figgy will extract the required metadata from the main cataloging system using the MMS-ID and create another metadata record in our Digital Maps and Geospatial Data Portal (https://maps.princeton.edu/). This metadata which is indexed in our Digital Maps and Geospatial Data Portal will allow users to search, view and download maps from our Portal.

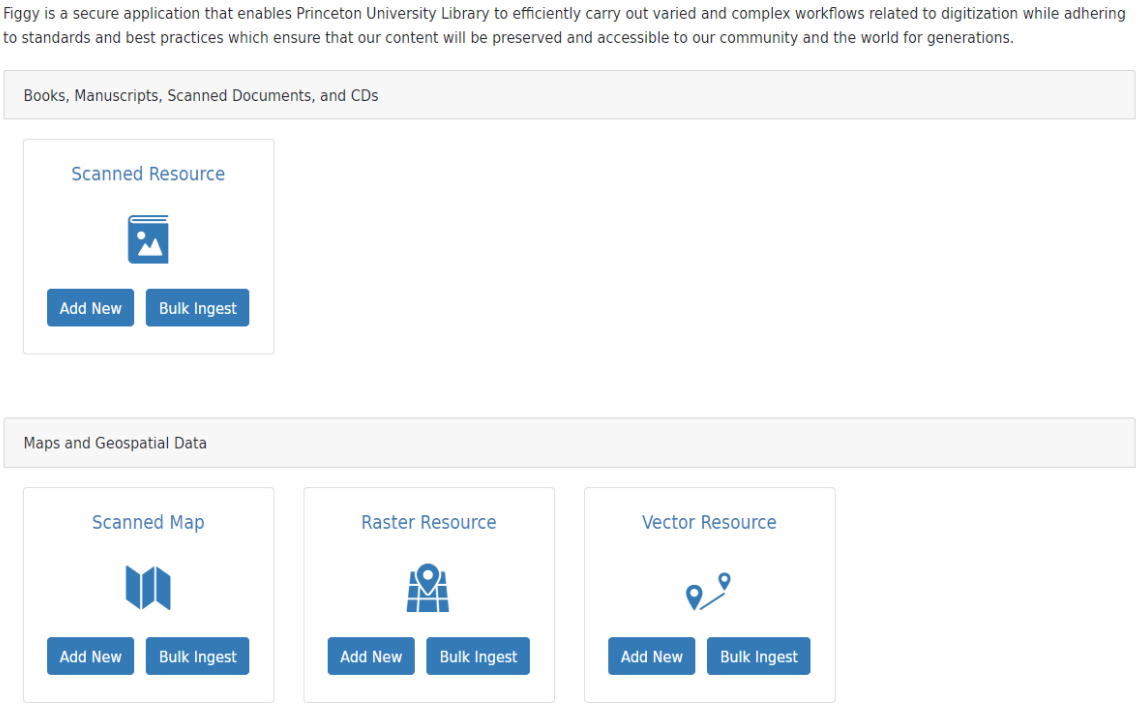

Figure 7: Figgy's Raster bulk ingest interface

When we upload the digital maps in Figgy, it will generate a unique URL with an ARK number (Archival Resource Keys)[3]. We add that URL in the MARC 856 field (Figure 8). Adding the unique URL with ARK number on MARC 856 will allow users to view and download the maps we upload on Figgy.

852 8	b| lewis c| map h| G7651 s250 i| .A7M3
856 4 1	u| http://arks.princeton.edu/ark:/88435/dc1257b365d z| See the map

Figure 8: Catalog recording showing MARC field 856

Conclusion

The workflow we developed in converting paper maps to geographic data and cataloging all expressions of the same map in one catalog record has allowed us to make our maps more useful to our researchers. The researchers can not only find different expressions of the same map in one catalog record but also, they can view and download the map in different products from one site. Since we have added the unique URL with Ark number to our main catalog record, once the patron finds the map in our catalog, they will not only see the catalog record of the map, but also will see the thumbnail image (Figure 9) of one map sheet on the side as well as the map viewer at the bottom of the page.

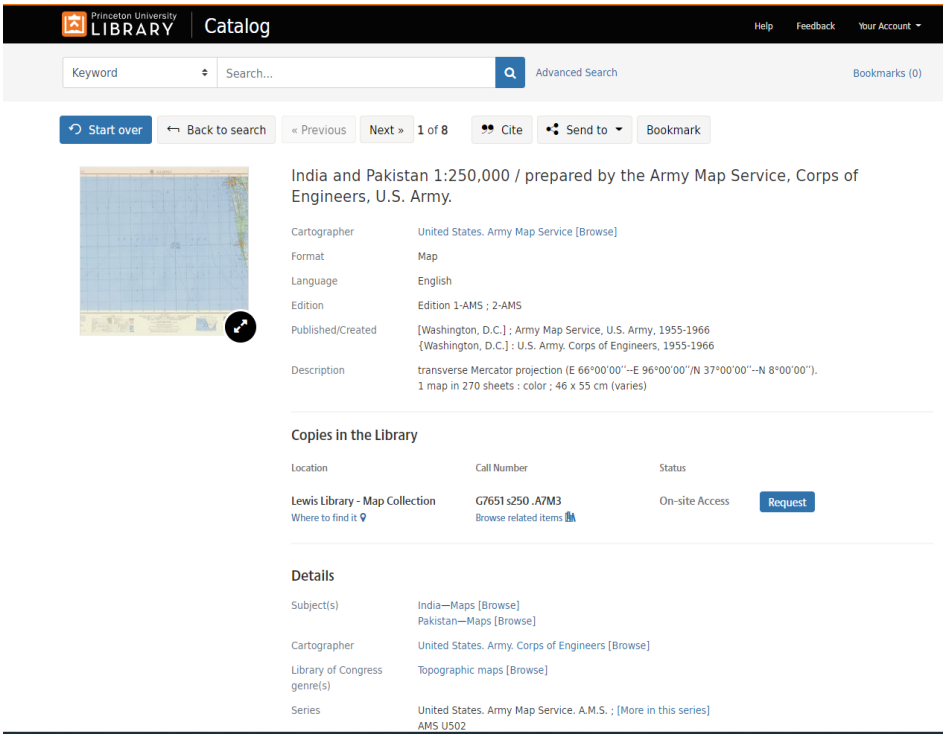

Figure 9: The main catalog interface

[3] https://arks.org

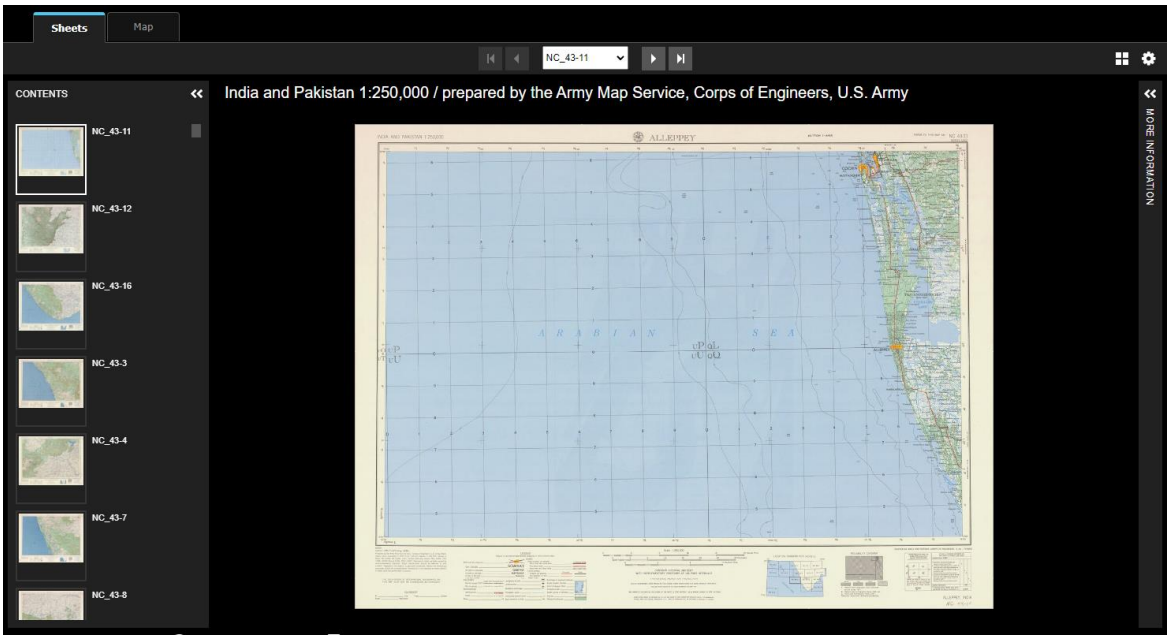

Figure 10: The map viewer interface

The map viewer (Figure 10) is designed in such a way that a researcher can view individual map sheets one at a time. However, if they want to see all the map sheets together as a mosaic map, then they need to select the map tab on the map viewer. Once the map tab is selected, they can view the mosaic map. It will allow the user to interact with the mosaic map (Figure 11).

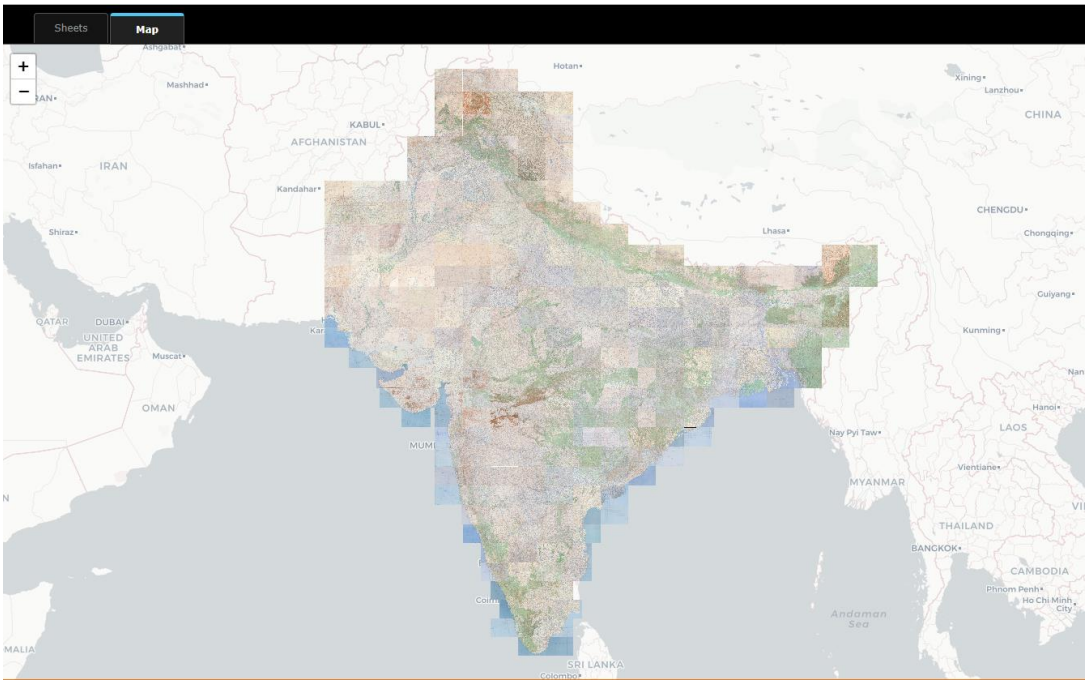

Figure 11: The mosaic map viewer interface

The map viewer linked to the main catalog record will allow the user to view individual map sheets and all the map sheets together as a mosaic map. It will allow the user to select individual sheets and download them either as scanned maps or georeferenced maps (with map collars) as a GeoTIFF file (Figure 12). In the future we will allow users to download the georeferenced maps without map collars.

Figure 12: A map download window

To view and interact with our map viewer, a user does not need any software. However, if a person wants to use our mosaic map as a base map in any GIS software packages that can open WMTS or XYZ Tiles services then they need to use our Digital Maps and Geospatial Data portal (https://maps.princeton.edu/). In this portal, the user needs to select "*Web services*" (Figure 13 &14) to open the Web services window, copy the URL of either WMTS or XYZ Tiles, depending on which service the user wants to add on their software, and access the mosaic map directly to their GIS software without downloading anything.

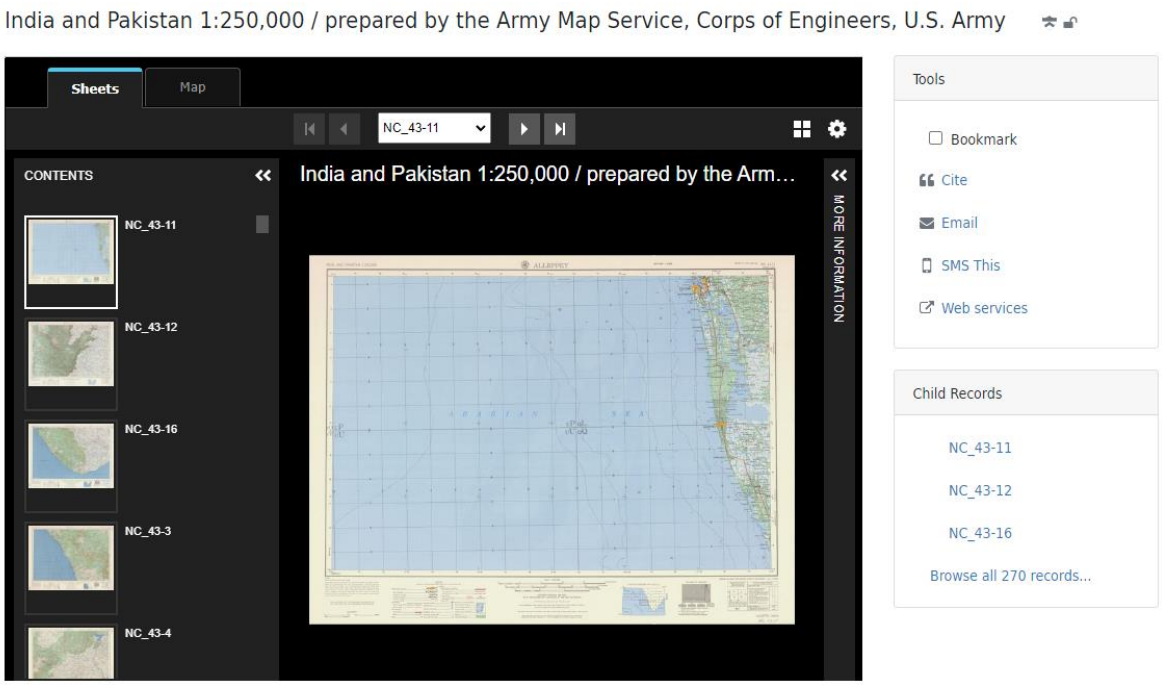

Figure 13: Web service location

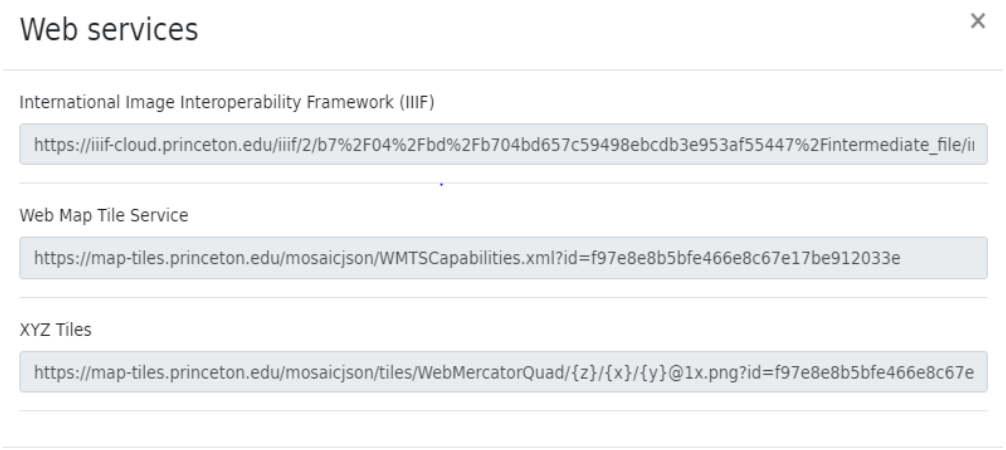

Figure 14: Web service URL

The following screenshots show examples of interfaces in QGIS software (Figure 15) to add WMTS and XYZ services from the Web services link.

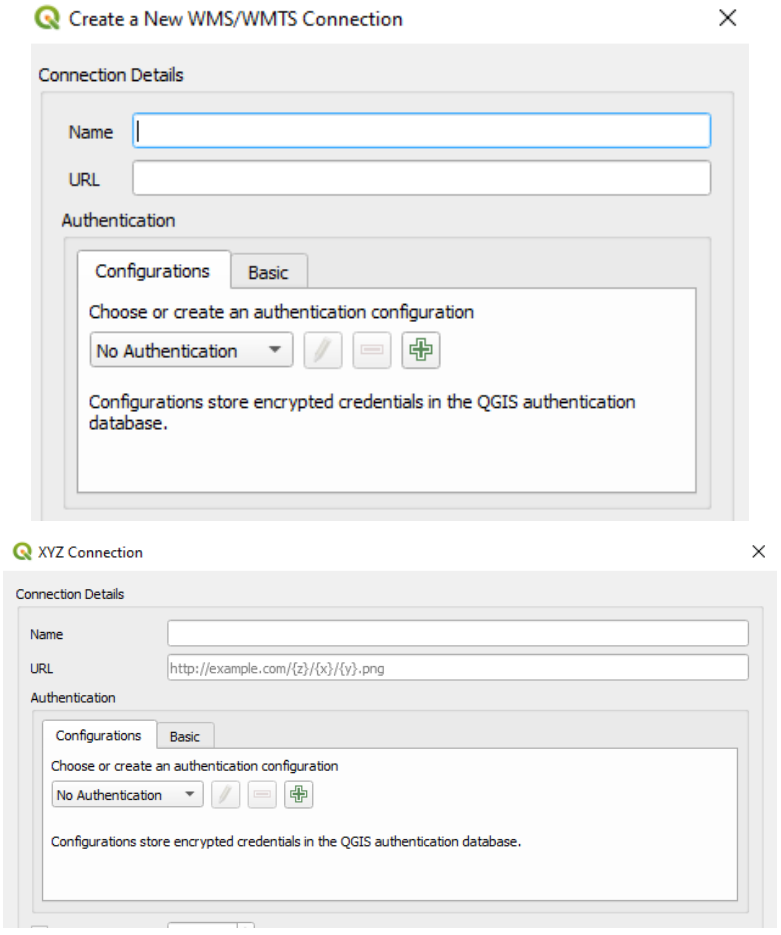

Figure 15: QGIS WMTS and XYZ connection windows

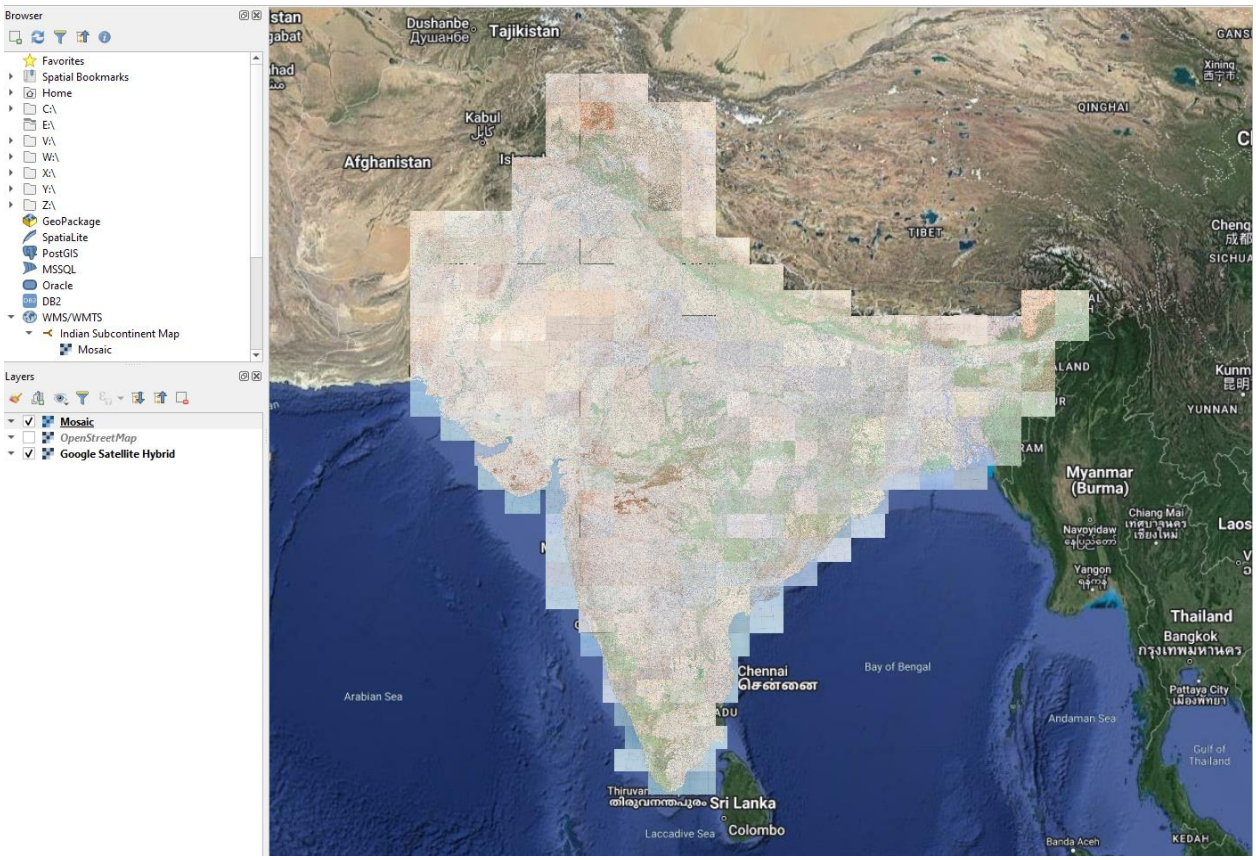

Figure 16: Mosaic map added on QGIS software

The above workflows and tools we have developed give a great deal of flexibility to researchers to access our maps as individual map sheets or mosaic maps, with or without GIS software. The mosaic map that merges all map sheets together can be viewed on a web browser, but they can also be viewed using GIS software packages without downloading the mosaic map (Figure 16). I believe that this will allow researchers of varying skill levels to access our digital map resources. The recently developed workflow has helped me achieve one of the goals I have had for our Library's Map and Geospatial Information Center, that is to convert paper maps to geographic data as much as we can. The paper maps converted to geographic data give our researchers more options to use our resources with other geospatial data.

References

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