UK OIL PRODUCTION REPORT

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Executive Summary

The energy company intends to perform an analysis of the UK Oil Production during past decades to identify possible oil exploration fields off the UK shore. The analysis requires to review offshore oil production data available between the period of 1980 and 2010.

The company has following objectives using the spatial data acquired:

- Explore spatial data to perform visualisation, identify coordinate system, types of data available, review attribute tables, and identify useful data.
- Link non-spatial database with a spatial vector dataset.
- Selecting and cleaning data for analysis.
- Produce continuous map using Kriging interpolation.
- Analyse spatial patterns.
- Identify spatial relations, visually and with tools.
- Analyse temporal change of spatially distributed properties.

At high level, the company has performed following spatial analysis:

- Explore and prepare the data for analysis.
- Find data for oil production between 1980-1995 and 1995-2010.
- Link data with spatial information on wells with the oil production data.
- Analyse the wells on map by geological basin, cartographic quadrant, and water depth.
- Map the oil production between 1980 – 1995 and 1995 – 2010.
- Identify visual patterns of oil production.
- Perform quantitative analysis of the oil production.
- Analyse patterns of change in oil production.
- Calculate difference in oil production between the periods and produce maps.
- Compare maps for production change.
- Apply interpolation technique to identify other possible oil fields for further exploration.

Introduction

Purpose

The energy company plans to perform analysis with estimate oil production based on historical data gathered for two periods, from 1980 to 1995 and 1995 to 2010. The company carries out tasks as enlisted and detailed in this report to analyse the data gathered, merge different datasets, apply filters, gather statistics, compare maps, and identify differences between the period and project the future estimates.

Tasks

Below is the list of tasks performed for the study.

1. Explore the available spatial layers.
2. Link spreadsheet data with the spatial database.
3. Analyse the distribution of wells by geological basin, by cartographic quadrant, and by water depth.
4. Derive maps for both the periods.
5. Examine the visual patterns of oil production.
6. Compare quantitatively the global production at the two periods of analysis.
7. Examine and describe patterns of change.
8. Calculate the change in production of each well and derive a new map.
9. Compare maps of production change.
10. Estimate new areas of future exploration using interpolation methods.

Tasks & Results

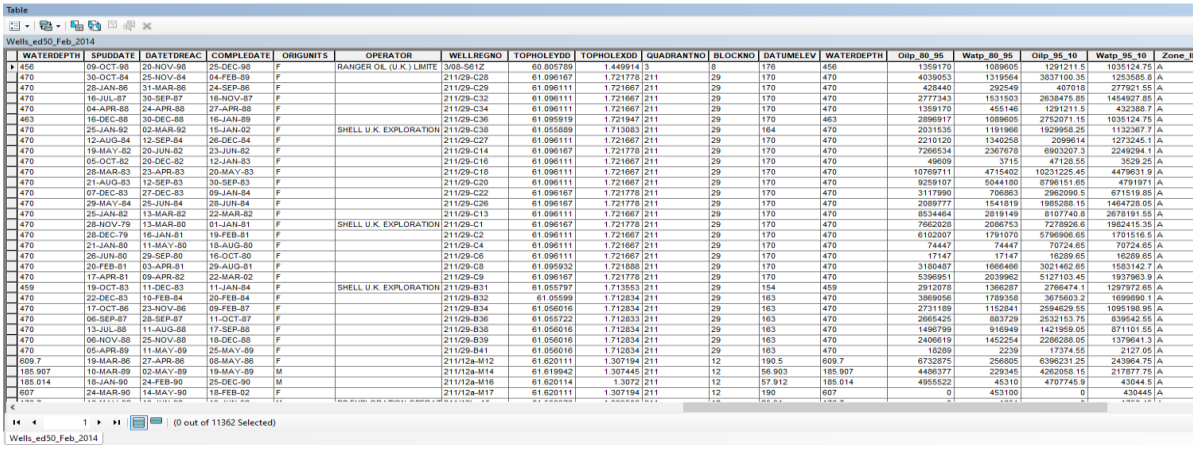
1: Exploration of Data Layers

Below is the initial analysis of the data layers made available for processing:

- There are 20 different shape files available for oil production study.
- The geographic coordinate sytem is GCP European 1950
- The files are vector files available are of the type point, line and polygon.
- The attribute tables with useful data are present for 20 shape files.
- There are 11,362 oil wells, 2,729 blocks.
- Further, 164 sub area with 118 discoveries, and additional 12 sub area with 22 discoveries performed by several licensed operators without WELLREGNO.
- There are 14 major and 72 sub geological basins are present around the UK offshore.
- 62 quadrant from 30 blocks are being licensed since 1964.
- 11 different sea areas have been marked around the UK.

2: Joining XLS and Attribute table.

The Wells_ed50_Feb_2014.shp shape file has attribute table which lists out 'Quadrant Number', 'Block Number', 'Well Co-ordinates', and other information for each well. Also, the Well_production.xls has additional data such as 'Elevation', 'Water Depth', and oil as well as water production between 1980 to 1995 and between 1995 to 2010. The spreadsheet and the shapefile attribute tables were joined using an approach detailed in Appendix A. Refer fig. 1 for the result produced for this task.



Table

Wells_ed50_Feb_2014

WATERDEPTH	SPUDDATE	DATETDREAC	COMPLEDATE	ORIGUNITS	OPERATOR	WELLREGNO	TOPHOLEYDD	TOPHOLEXDD	QUADRANTNO	BLOCKNO	DATUMELEV	WATERDEPTH	Oilp_80_95	Watp_80_95	Oilp_95_10	Watp_95_10	Zone_I
456	09-OCT-98	20-NOV-98	25-DEC-98	F	RANGER OIL (U.K.) LIMITE	3/08-S612	60.805789	1.449914	3	8	176	456	1359170	1089605	1291211.5	1035124.75	A
470	30-OCT-84	25-NOV-84	04-FEB-89	F		211/29-C26	61.096167	1.721778	211	29	170	470	4039053	1319564	3837100.35	1253585.8	A
470	28-JAN-86	31-MAR-86	24-SEP-86	F		211/29-C29	61.096111	1.721667	211	29	170	470	428440	292549	407018	277921.55	A
470	16-JUL-87	30-SEP-87	16-NOV-87	F		211/29-C32	61.096111	1.721667	211	29	170	470	2777343	1531503	2638475.85	1454927.85	A
470	04-APR-88	24-APR-88	27-APR-88	F		211/29-C34	61.096111	1.721667	211	29	170	470	1359170	455146	1291211.5	432388.7	A
463	16-DEC-88	30-DEC-88	16-JAN-89	F		211/29-C36	61.095919	1.721947	211	29	170	463	2896917	1089605	2752071.15	1035124.75	A
470	25-JAN-92	02-MAR-92	15-JAN-02	F	SHELL U.K. EXPLORATION	211/29-C38	61.055889	1.713083	211	29	164	470	2031535	1191966	1929958.25	1132367.7	A
470	12-AUG-84	12-SEP-84	26-DEC-84	F		211/29-C27	61.096111	1.721667	211	29	170	470	2216120	1340258	2099614	1273245.1	A
470	19-MAY-82	20-JUN-82	23-JUN-82	F		211/29-C14	61.096167	1.721778	211	29	170	470	7266534	2367678	6903207.3	2249294.1	A
470	05-OCT-82	20-DEC-82	12-JAN-83	F		211/29-C16	61.096111	1.721667	211	29	170	470	49609	3715	47128.55	3529.25	A
470	28-MAR-83	23-APR-83	20-MAY-83	F		211/29-C18	61.096111	1.721667	211	29	170	470	10769711	4715402	10231225.45	4479631.9	A
470	21-AUG-83	12-SEP-83	30-SEP-83	F		211/29-C20	61.096111	1.721667	211	29	170	470	9259107	5044180	8796151.65	4791971	A
470	07-DEC-83	27-DEC-83	09-JAN-84	F		211/29-C22	61.096167	1.721778	211	29	170	470	3117990	706863	2962090.5	671519.85	A
470	29-MAY-84	25-JUN-84	28-JUN-84	F		211/29-C26	61.096167	1.721778	211	29	170	470	2089777	1541819	1985288.15	1464728.05	A
470	25-JAN-82	13-MAR-82	22-MAR-82	F		211/29-C13	61.096111	1.721667	211	29	170	470	8534464	2819149	8107740.8	2678191.55	A
470	28-NOV-79	13-MAR-80	01-JAN-81	F	SHELL U.K. EXPLORATION	211/29-C1	61.096167	1.721778	211	29	170	470	7662028	2086753	7278926.6	1982415.35	A
470	28-DEC-79	16-JAN-81	19-FEB-81	F		211/29-C2	61.096111	1.721667	211	29	170	470	6102007	1791070	5796906.65	1701516.5	A
470	21-JAN-80	11-MAY-80	18-AUG-80	F		211/29-C4	61.096111	1.721667	211	29	170	470	74447	74447	70724.65	70724.65	A
470	26-JUN-80	29-SEP-80	16-OCT-80	F		211/29-C6	61.096111	1.721667	211	29	170	470	17147	17147	16289.65	16289.65	A
470	20-FEB-81	03-APR-81	29-AUG-81	F		211/29-C8	61.095932	1.721888	211	29	170	470	3180487	1666466	3021462.65	1583142.7	A
470	17-APR-81	09-APR-82	22-MAR-02	F		211/29-C9	61.096167	1.721778	211	29	170	470	5396951	2039962	5127103.45	1937963.9	A
459	19-OCT-83	11-DEC-83	11-JAN-84	F	SHELL U.K. EXPLORATION	211/29-B31	61.055797	1.713553	211	29	154	459	2912078	1366287	2766474.1	1297972.65	A
470	22-DEC-83	10-FEB-84	20-FEB-84	F		211/29-B32	61.05599	1.712834	211	29	163	470	3869056	1789358	3675603.2	1699890.1	A
470	17-OCT-86	23-NOV-86	09-FEB-87	F		211/29-B34	61.056016	1.712834	211	29	163	470	2731189	1152841	2594629.55	1095198.95	A
470	06-SEP-87	28-SEP-87	11-OCT-87	F		211/29-B36	61.055722	1.712833	211	29	163	470	2665425	883729	2532153.75	839542.55	A
470	13-JUL-88	11-AUG-88	17-SEP-88	F		211/29-B38	61.056016	1.712834	211	29	163	470	1496799	916949	1421959.05	871101.55	A
470	06-NOV-88	25-NOV-88	18-DEC-88	F		211/29-B39	61.056016	1.712834	211	29	163	470	2406619	1452254	2286286.05	1379641.3	A
470	05-APR-89	11-MAY-89	25-MAY-89	F		211/29-B41	61.056016	1.712834	211	29	163	470	18289	2239	17374.55	2127.05	A
609.7	19-MAR-86	27-APR-86	08-MAY-86	F		211/12a-M12	61.620111	1.307194	211	12	190.5	609.7	6732875	256805	6396231.25	243964.75	A
185.907	10-MAR-89	02-MAY-89	19-MAY-89	M		211/12a-M14	61.619942	1.307445	211	12	56.903	185.907	4486377	229345	4262058.15	217877.75	A
185.014	18-JAN-90	24-FEB-90	25-DEC-90	M		211/12a-M16	61.620114	1.3072	211	12	57.912	185.014	4955522	45310	4707745.9	43044.5	A
607	24-MAR-90	14-MAY-90	18-FEB-02	F		211/12a-M17	61.620111	1.307194	211	12	190	607	0	453100	0	430445	A

(0 out of 11362 Selected)

Wells_ed50_Feb_2014

Fig. 1. Attribute table of 'Wells_ed50_Feb_2014.shp' joined with 'Data' tab from 'Wells_production.xls'.

Above table in fig. 1 shows the additional columns TOPHOLEYDD, TOPHOLEXDD, QUADRANTNO, BLOCKNO, DATUMELEV, WATERDEPTH, Oilp_80_95, Watp_80_95, Oilp_95_10, Watp_95_10 and Zone ID joined from the Wells_production.xls with the attribute table of Wells_ed50_Feb_2014.shp.

3. Distribution of wells by geological basin, cartographic quadrant, and water depth

There are 512 quadrants identified around the UK region, however not all of them have been identified with a quadrant number. There are 82 quadrants where wells have been found, and most of which are found to be off the UK's eastern shore. Further, it is found that 1,354 wells are clustered in a single quadrant number 211 present off the north-eastern shore of the UK as shown in fig. 2. Also, off the north-east shore, there are more than 7,000 wells found to be present out of 11,362 wells. On the other hand, quadrants found off the south-eastern shore of the UK only has less than 350 wells.

Considering water depth, the deepest well found was 6,189 meters deep, while the wells were also found to be less than 100 meters in depth as well. Further, 127 wells were found to have water depth of 466 meters as shown in fig. 3, whereas average depth of the wells was 345 meters approximately. Although, some of the wells had depth of 1 meter or below, however this must be considered as data error and should be ignored from consideration.

Further, majority of wells are found to be clustered in Northern, Central and Southern North Sea Basin, whereas some of the wells are also found in West of Shetland Basin and Irish Sea Basin. Furthermore, very few wells were found to be scattered across Rockall

Tasks & Results

Basin, Cardigan Basin, South West Approaches Basin, and Anglo-Paris basin. Refer fig. 4 for number of wells spread across different geological basins.

Please refer Appendix B for more details about the process.

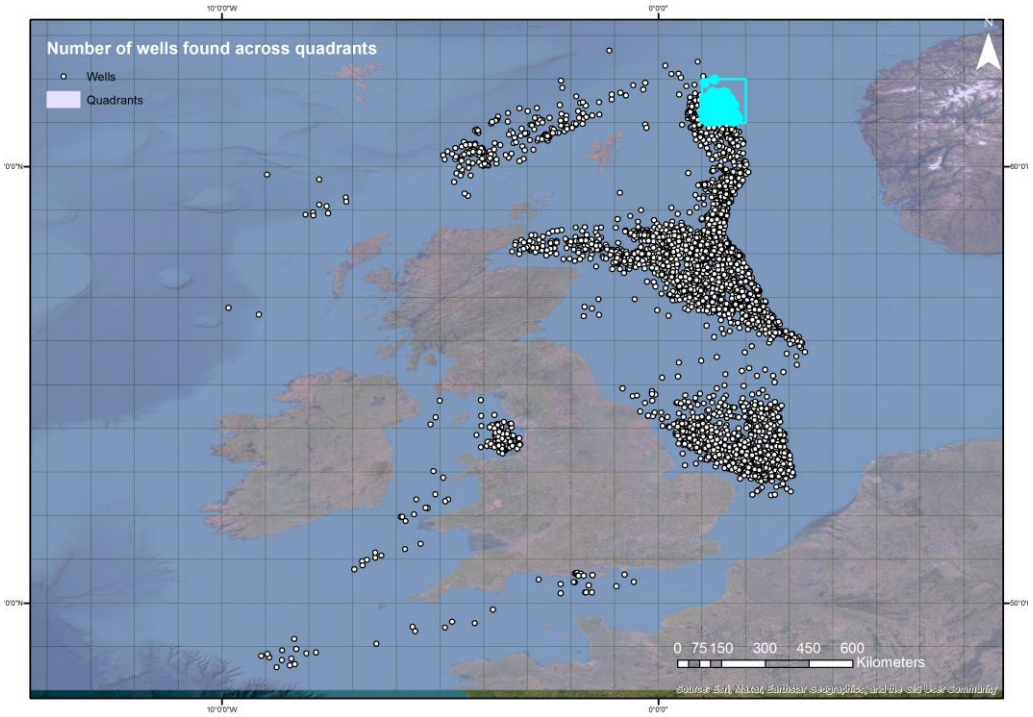


Fig. 2. 1,354 wells were located in a single quadrant number 211.

Table

Wells

PLATFORM	SLOTNO	DRILLSEQNO	WELLSUFFIX	NAME	ORIGINTENT	DATUMELEV	DATUMTYPE	GROUNDELEV	WATERDEPTH	SPUDDATE	DATETDREAC	COMPLEDATE	ORIGUNITS	OPERATOR
		4			E	79	KB	0	289	22-JAN-93	09-FEB-93	14-FEB-93	F	
		1			E	106	RT	0	59	26-MAR-93	12-APR-93	12-APR-93	F	CNR INTERNATIONAL (U.K.) LIMITED
P		5			A	83	KB	0	597	31-AUG-92	26-OCT-92	18-DEC-92	F	SHELL U.K. EXPLORATION & PRODUCTI
		10			A	90	KB	0	231	23-DEC-92	16-JAN-93	13-FEB-93	F	
		48			E	88	KB	0	466	30-DEC-92	15-FEB-93	21-FEB-93	F	
A	05	6			D	126.646	KB	0	137.8	15-DEC-92	15-FEB-93	27-JUN-93	F	CONOCOPHILLIPS (U.K.) LIMITED
A	A-15	39			D	117	KB	0	466	01-NOV-92	08-FEB-93	11-APR-93	F	SHELL U.K. EXPLORATION & PRODUCTI
D	D-46	37			D	117	KB	0	466	30-NOV-92	05-JUN-93	05-JUN-93	F	SHELL U.K. EXPLORATION & PRODUCTI
M	F3	2	Z		D	80	KB	0	447	12-FEB-93	15-MAR-93	02-APR-93	F	
A	13	3	Z		D	196	KB	0	453	01-NOV-92	21-NOV-92	21-NOV-92	F	CHEVRON NORTH SEA LIMITED
M	18	20			D	185	KB	0	512	26-JUL-82	20-AUG-82	28-AUG-82	F	CONOCOPHILLIPS (U.K.) LIMITED
M	16	21			D	185	KB	0	512	28-AUG-82	29-JUN-83	08-JUL-83	F	CONOCOPHILLIPS (U.K.) LIMITED
M	12	1			D	185	KB	0	512	22-JUN-80	12-JUL-80	25-JUL-80	F	CONOCOPHILLIPS (U.K.) LIMITED
M	03	2			D	185	KB	0	512	27-JUL-80	26-OCT-80	27-OCT-80	F	
M	9	5			D	185	KB	0	512	11-JAN-81	15-MAR-81	27-MAR-81	F	
M	2	7			D	185	KB	0	512	24-JUL-80	07-MAY-81	12-MAY-81	F	
M	21	9			D	185	KB	0	512	05-JUN-81	21-JUN-81	03-JUL-81	F	
M	25	10			D	185	KB	0	512	03-JUL-81	28-JUL-81	04-AUG-81	F	
M	23	12			D	185	KB	0	512	30-MAY-80	25-SEP-81	03-OCT-81	F	
		21			A	82	KB	0	563	07-APR-80	31-MAY-80	30-JUN-80	F	
		23			A	82	KB		535	01-NOV-81	01-JAN-82	22-JAN-82	F	THE OIL AND PIPELINES AGENCY [OPA]
		25			E	85	KB	0	558	02-MAR-92	13-APR-92	21-APR-92	F	
		2			E	77	KB		512	12-JUL-75	13-AUG-75	29-JUL-78	F	PHILLIPS 66 LIMITED
		6			E	80	KB		515	11-NOV-76	26-DEC-76	13-JAN-77	F	PHILLIPS 66 LIMITED
A	A-53	54			D	147	KB	0	532	19-DEC-89	27-JAN-90	06-FEB-90	F	
N	1	1			A	85	KB		577	05-SEP-76	26-DEC-76	17-OCT-89	F	BP EXPLORATION OPERATING COMPAN

1 (127 out of 11362 Selected)

Wells

Fig. 3. 127 wells are found to have water depth of 466 meters as per the filter applied to the attribute table.

Tasks & Results

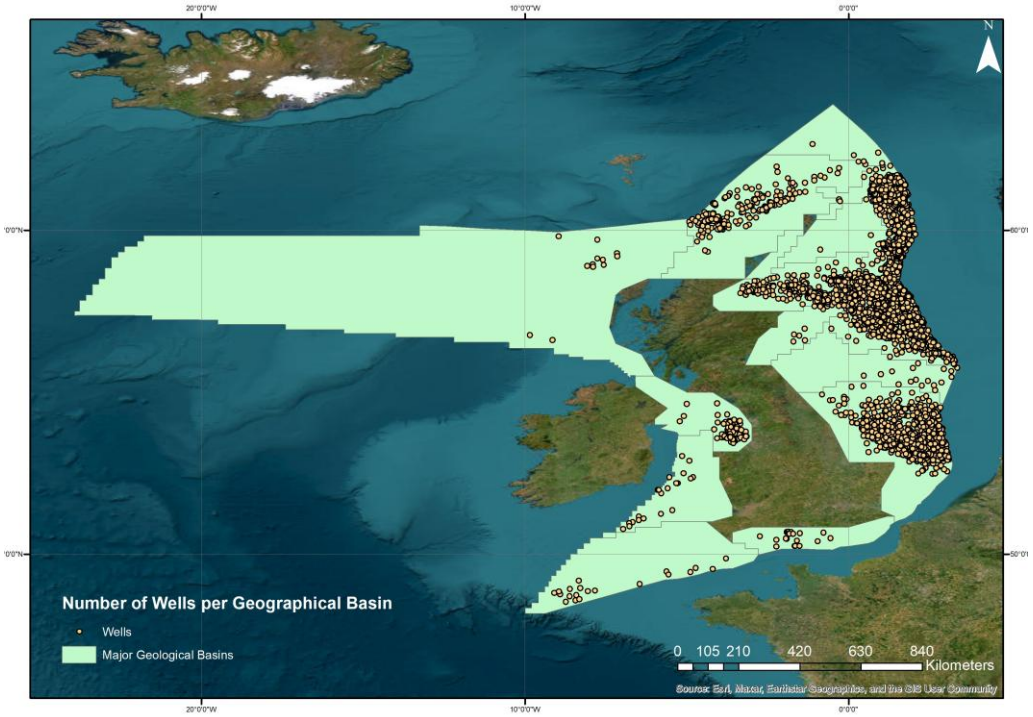


Fig. 4. Number of wells spread across Geological Basins.

4: Oil Production between 1980 – 1995 and 1995 - 2010

The Wells_Production.xls has two columns, Oilp_80_95 and Oilp_95_10. These columns represent amount of oil produced for a given well during the period 1980 - 1995 and 1995 - 2010 respectively. After joining the excel spreadsheet with the attribute table of Wells_ed50_Feb_2014.shp, the amount of oil found in the oil wells can be visualised on maps for both the periods as shown in fig. 5 and fig. 6. Further, the oil production for each well has been categorised with different colours for different range of oil production as well.

Please refer Appendix C for more details about the process.

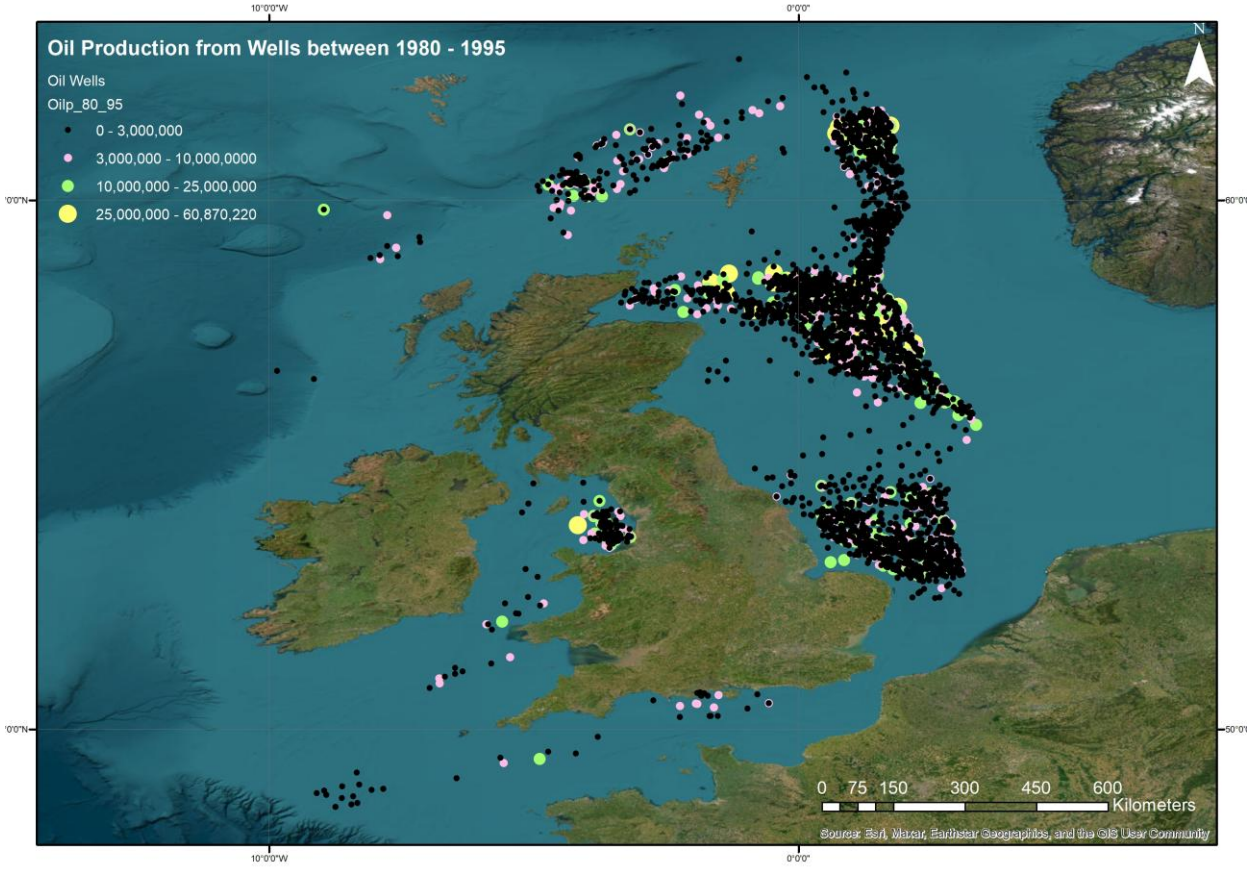


Fig. 5. Oil Production from wells between 1980 – 1995.

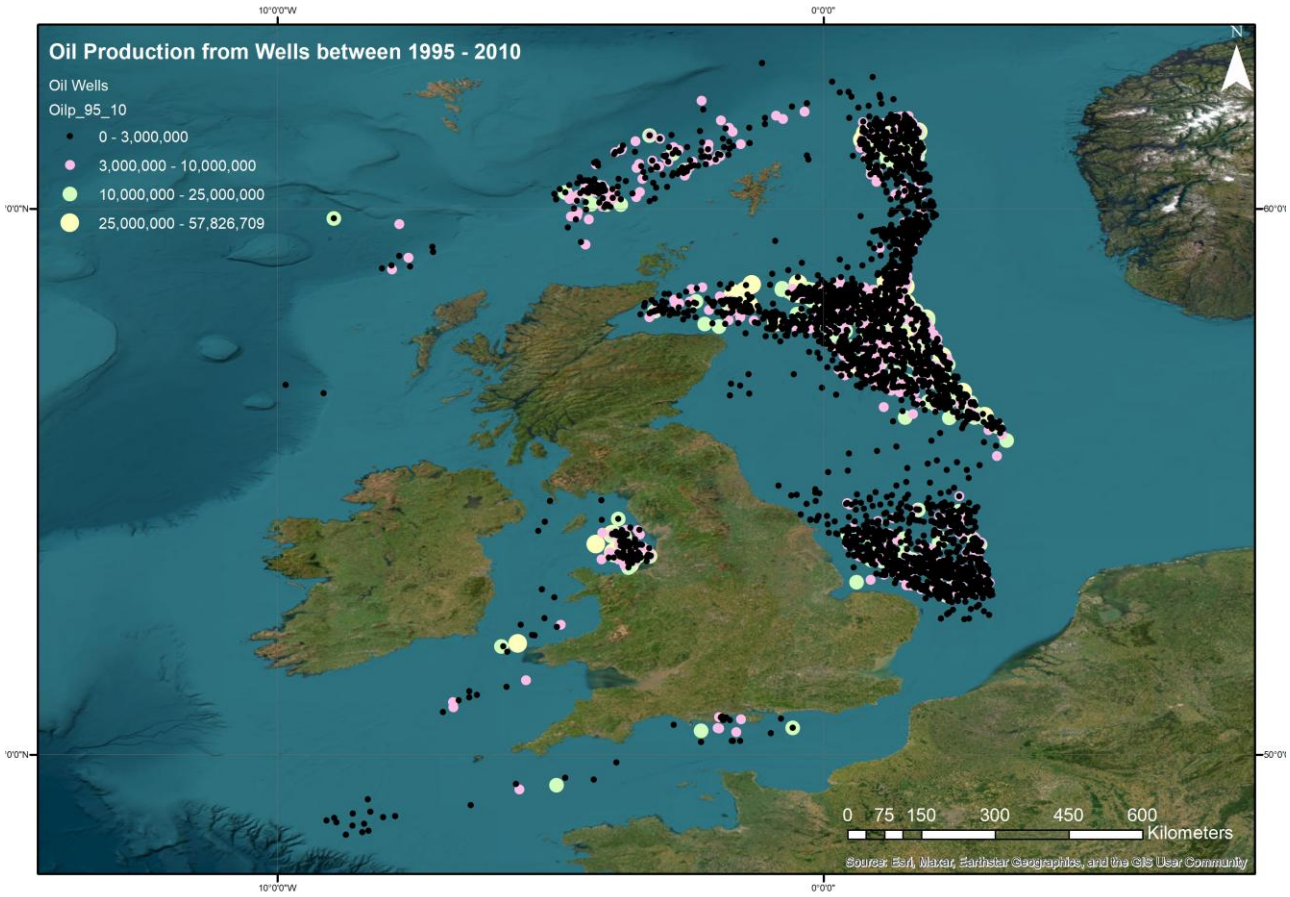


Fig. 6. Oil Production from Wells between 1995 – 2010.

5: Visual patterns of Oil Production.

As it can be seen from fig. 5 and fig. 6 that most of the oil produced during 1980 – 1995 and 1995 – 2010 were off the eastern, north-eastern, and south-eastern shores of the UK. Also, majority of oil wells during both the periods were producing less than 3 million metric tons of oil. Further, large number of oil wells located off the eastern, north-eastern and south-eastern shore were found to be far away from the UK shores, whereas most of the oil wells located off the western and southern shores of the UK were comparatively closer to the UK shores.

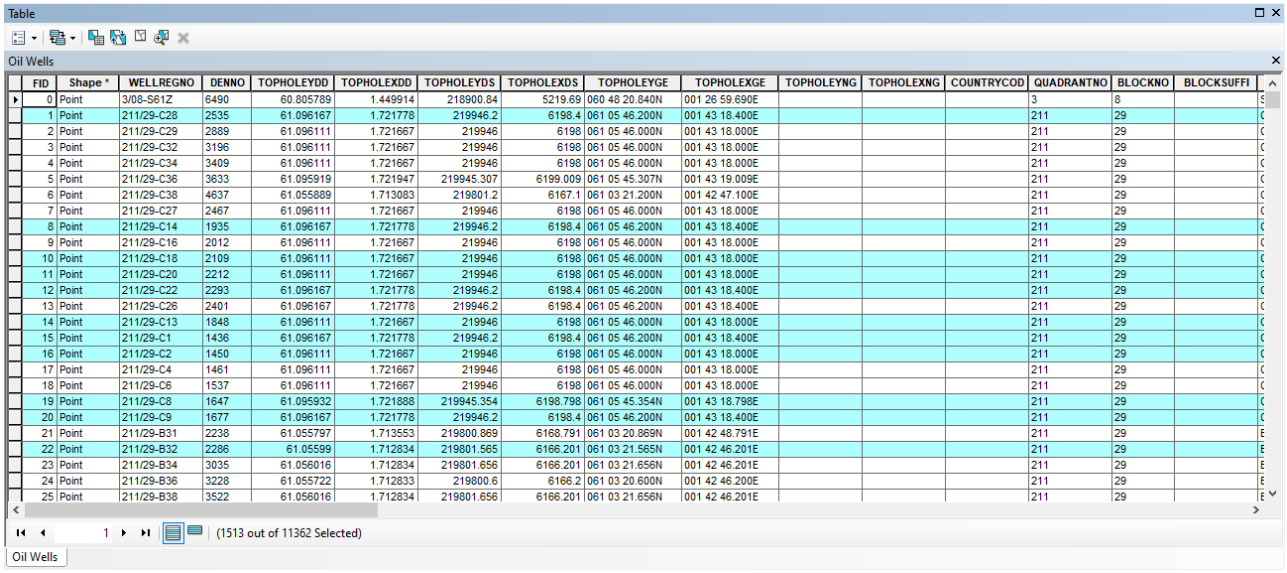
6: Quantitative analysis of Oil Production.

Tasks & Results

By reviewing the attribute table as shown in fig. 7, it is noticeable that there are only 1,513 wells out of 11,362 had produced more than 3 million metric tons of oil between 1980 and 1995. Whereas, only 1,549 out of 11,362 wells had produced more than 3 million metric tons of oil between 1995 and 2010 as shown in fig. 8. This means little over 13% of all the wells had produced more than 3,000,000 metric tons of oil in both the period.

Further, it was noticed from the attribute table that only 2,410 oil wells had produced more oil between 1980 and 1995 compared to the oil produced between 1995 and 2010. On the other hand, 2,604 oil wells had produced more oil between 1995 and 2010 compared to the previous period.

Please refer to the Appendix D for more details about the process.



Table

Oil Wells

FID	Shape *	WELLREGNO	DENNO	TOPHOLEYDD	TOPHOLEXDD	TOPHOLEYDS	TOPHOLEXDS	TOPHOLEYGE	TOPHOLEXGE	TOPHOLEYNG	TOPHOLEXNG	COUNTRYCOD	QUADRANTNO	BLOCKNO	BLOCKSUFFI
0	Point	3/08-S61Z	6490	60.805789	1.449914	218900.84	5219.69	060 48 20.840N	001 26 59.690E				3	8	
1	Point	211/29-C28	2535	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
2	Point	211/29-C29	2889	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
3	Point	211/29-C32	3196	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
4	Point	211/29-C34	3409	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
5	Point	211/29-C36	3633	61.095919	1.721947	219945.307	6199.009	061 05 45.307N	001 43 19.009E				211	29	
6	Point	211/29-C38	4637	61.055889	1.713083	219801.2	6167.1	061 03 21.200N	001 42 47.100E				211	29	
7	Point	211/29-C27	2467	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
8	Point	211/29-C14	1935	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
9	Point	211/29-C16	2012	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
10	Point	211/29-C18	2109	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
11	Point	211/29-C20	2212	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
12	Point	211/29-C22	2293	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
13	Point	211/29-C26	2401	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
14	Point	211/29-C13	1848	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
15	Point	211/29-C1	1436	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
16	Point	211/29-C2	1450	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
17	Point	211/29-C4	1461	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
18	Point	211/29-C6	1537	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
19	Point	211/29-C8	1647	61.095932	1.721888	219945.354	6198.798	061 05 45.354N	001 43 18.798E				211	29	
20	Point	211/29-C9	1677	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
21	Point	211/29-B31	2238	61.055797	1.713553	219800.869	6168.791	061 03 20.869N	001 42 48.791E				211	29	
22	Point	211/29-B32	2286	61.05599	1.712834	219801.565	6166.201	061 03 21.565N	001 42 46.201E				211	29	
23	Point	211/29-B34	3035	61.056016	1.712834	219801.656	6166.201	061 03 21.656N	001 42 46.201E				211	29	
24	Point	211/29-B36	3228	61.055722	1.712833	219800.6	6166.2	061 03 20.600N	001 42 46.200E				211	29	
25	Point	211/29-B38	3522	61.056016	1.712834	219801.656	6166.201	061 03 21.656N	001 42 46.201E				211	29	

(1513 out of 11362 Selected)

Oil Wells

Fig. 7. The attribute table of Wells_ed50_Feb_2014.shp showing only 1,513 oil wells had produced more than 3,000,000 metric tons of oil between 1980 and 1995.

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Table

Oil Wells

FID	Shape *	WELLREGNO	DENNO	TOPHOLEYDD	TOPHOLEXDD	TOPHOLEYDS	TOPHOLEXDS	TOPHOLEYGE	TOPHOLEXGE	TOPHOLEYNG	TOPHOLEXNG	COUNTRYCOD	QUADRANTNO	BLOCKNO	BLOCKSUFFI
0	Point	3/08-S61Z	6490	60.805789	1.449914	218900.84	5219.69	060 48 20.840N	001 26 59.690E				3	8	
1	Point	211/29-C28	2535	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
2	Point	211/29-C29	2889	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
3	Point	211/29-C32	3196	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
4	Point	211/29-C34	3409	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
5	Point	211/29-C36	3633	61.095919	1.721947	219945.307	6199.009	061 05 45.307N	001 43 19.009E				211	29	
6	Point	211/29-C38	4637	61.055889	1.713083	219801.2	6167.1	061 03 21.200N	001 42 47.100E				211	29	
7	Point	211/29-C27	2467	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
8	Point	211/29-C14	1935	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
9	Point	211/29-C16	2012	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
10	Point	211/29-C18	2109	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
11	Point	211/29-C20	2212	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
12	Point	211/29-C22	2293	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
13	Point	211/29-C26	2401	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
14	Point	211/29-C13	1848	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
15	Point	211/29-C1	1436	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
16	Point	211/29-C2	1450	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
17	Point	211/29-C4	1461	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
18	Point	211/29-C6	1537	61.096111	1.721667	219946	6198	061 05 46.000N	001 43 18.000E				211	29	
19	Point	211/29-C8	1647	61.095932	1.721888	219945.354	6198.798	061 05 45.354N	001 43 18.798E				211	29	
20	Point	211/29-C9	1677	61.096167	1.721778	219946.2	6198.4	061 05 46.200N	001 43 18.400E				211	29	
21	Point	211/29-B31	2238	61.055797	1.713553	219800.869	6168.791	061 03 20.869N	001 42 48.791E				211	29	
22	Point	211/29-B32	2286	61.05599	1.712834	219801.565	6166.201	061 03 21.565N	001 42 46.201E				211	29	
23	Point	211/29-B34	3035	61.056016	1.712834	219801.656	6166.201	061 03 21.656N	001 42 46.201E				211	29	
24	Point	211/29-B36	3228	61.055722	1.712833	219800.6	6166.2	061 03 20.600N	001 42 46.200E				211	29	
25	Point	211/29-B38	3522	61.056016	1.712834	219801.656	6166.201	061 03 21.656N	001 42 46.201E				211	29	

1 (1549 out of 11362 Selected)

Oil Wells

Fig. 8. The attribute table of Wells_ed50_Feb_2014.shp showing only 1,549 oil wells had produced more than 3,000,000 metric tons of oil between 1995 and 2010.

7. Patterns of change in Oil Production.

From the histogram generated for both the periods as shown in fig. 9, it can be noticed that 11,000 oil wells had produced 12,174,044 metric tons of oil between 1980 and 1995. Whereas the same number of oil wells had produced comparatively lower amount of oil with 11,565,341.8 metric tons between 1995 and 2010 period as shown in fig. 10 below.

Please refer to the Appendix D for more details about the process.

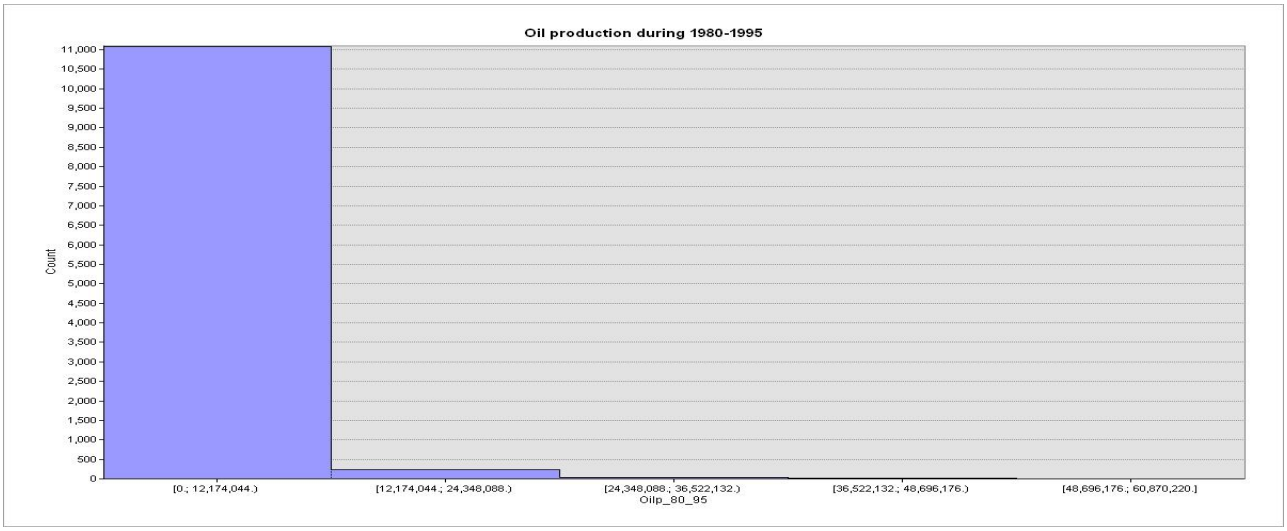


Fig. 9. The histogram of oil wells between the period of 1980 and 1995.

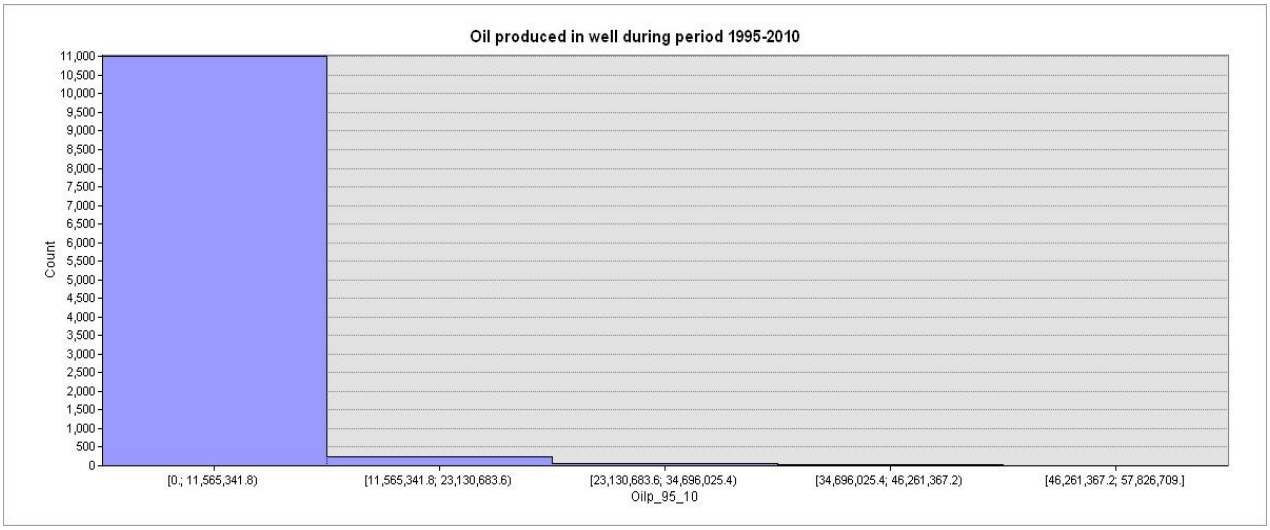


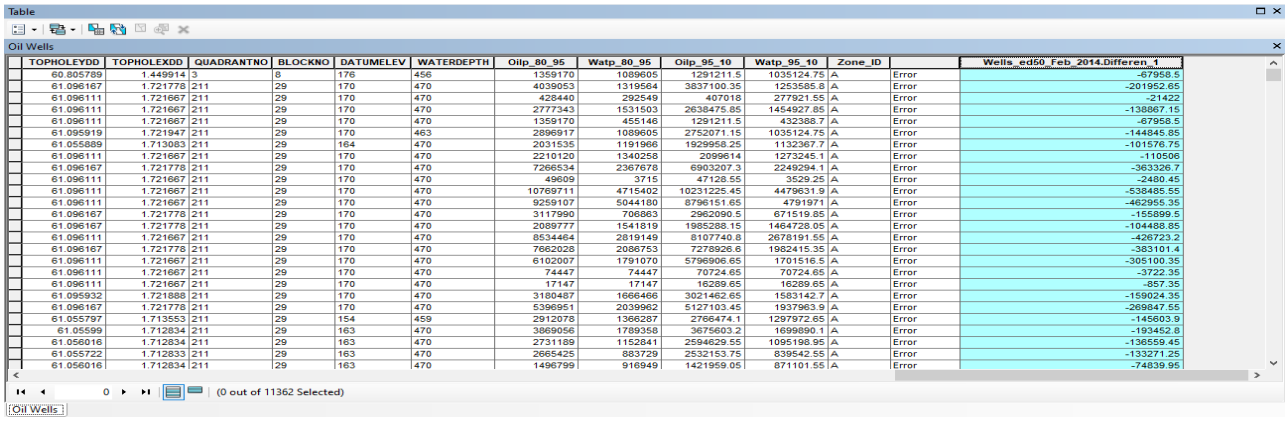
Fig. 10. The histogram of oil wells between the period of 1995 and 2010.

8. Calculating difference of change in oil production with derived map.

To observe patterns, the difference of oil was calculated between the two data columns representing oil production between 1995 to 2010 named as Oilp_95_10 and oil production between 1980 to 1995 named as Oilp_80_95.

The below attribute table in fig. 11 shows the difference calculated between the above-mentioned fields for each well and the result captured in highlighted column as shown. The negative values in the column represent that the oil production had decreased between 1995 to 2010 compared to the oil production between 1980 to 1995. Whereas the positive value in the column shows that the oil production had increased between 1995 to 2010 compared to the previous period.

Please refer to the Appendix E for more details about the process.



Table

Oil Wells

TOPHOLEYDD	TOPHOLEXDD	QUADRANTNO	BLOCKNO	DATUMELEV	WATERDEPTH	Oilp_80_95	Watp_80_95	Oilp_95_10	Watp_95_10	Zone_ID		Wells_ed50_Feb_2014.Differen_1
60.805789	1.449914	3	8	176	456	1359170	1089605	1291211.5	1035124.75	A	Error	-67958.5
61.096167	1.721778	211	29	170	470	4039053	1319564	3837100.35	1253585.8	A	Error	-201952.65
61.096111	1.721667	211	29	170	470	428440	292549	407018	277921.55	A	Error	-21422
61.096111	1.721667	211	29	170	470	2777343	1531503	2638475.85	1454927.85	A	Error	-138867.15
61.096111	1.721667	211	29	170	470	1359170	455146	1291211.5	432388.7	A	Error	-67958.5
61.095919	1.721947	211	29	170	463	2896917	1089605	2752071.15	1035124.75	A	Error	-144845.85
61.055889	1.713083	211	29	164	470	2031535	1191966	1929958.25	1132367.7	A	Error	-101576.75
61.096111	1.721667	211	29	170	470	2210120	1340258	2099614	1273245.1	A	Error	-110506
61.096167	1.721778	211	29	170	470	7266534	2367678	6903207.3	2249294.1	A	Error	-363326.7
61.096111	1.721667	211	29	170	470	49609	3715	47128.55	3529.25	A	Error	-2480.45
61.096111	1.721667	211	29	170	470	10769711	4715402	10231225.45	4479631.9	A	Error	-538485.55
61.096111	1.721667	211	29	170	470	9259107	5044180	8796151.65	4791971	A	Error	-462955.35
61.096167	1.721778	211	29	170	470	3117990	708863	2962090.5	671519.85	A	Error	-155899.5
61.096167	1.721778	211	29	170	470	2089777	1541819	1985288.15	1464728.05	A	Error	-104488.85
61.096111	1.721667	211	29	170	470	8534464	2819149	8107740.8	2678191.55	A	Error	-426723.2
61.096167	1.721778	211	29	170	470	7662028	2086753	7278926.6	1982415.35	A	Error	-383101.4
61.096111	1.721667	211	29	170	470	6102007	1791070	5796906.65	1701516.5	A	Error	-305100.35
61.096111	1.721667	211	29	170	470	74447	74447	70724.65	70724.65	A	Error	-3722.35
61.096111	1.721667	211	29	170	470	17147	17147	16289.65	16289.65	A	Error	-857.35
61.095932	1.721888	211	29	170	470	3180487	1666466	3021462.65	1583142.7	A	Error	-159024.35
61.096167	1.721778	211	29	170	470	5396951	2039962	5127103.45	1937963.9	A	Error	-269847.55
61.055797	1.713553	211	29	154	459	2912078	1366287	2766474.1	1297972.65	A	Error	-145603.9
61.05599	1.712834	211	29	163	470	3869056	1789358	3675603.2	1699890.1	A	Error	-193452.8
61.056016	1.712834	211	29	163	470	2731189	1152841	2594629.55	1095198.95	A	Error	-136559.45
61.055722	1.712833	211	29	163	470	2665425	883729	2532253.75	839542.55	A	Error	-133271.25
61.056016	1.712834	211	29	163	470	1496799	916949	1421959.05	871101.55	A	Error	-74839.95

(0 out of 11362 Selected)

Oil Wells

Fig. 11. The new column added to the attribute table to show the difference in oil production between two periods.

Fig. 12 shows the difference field calculated and mapped for each well per the geological basin.

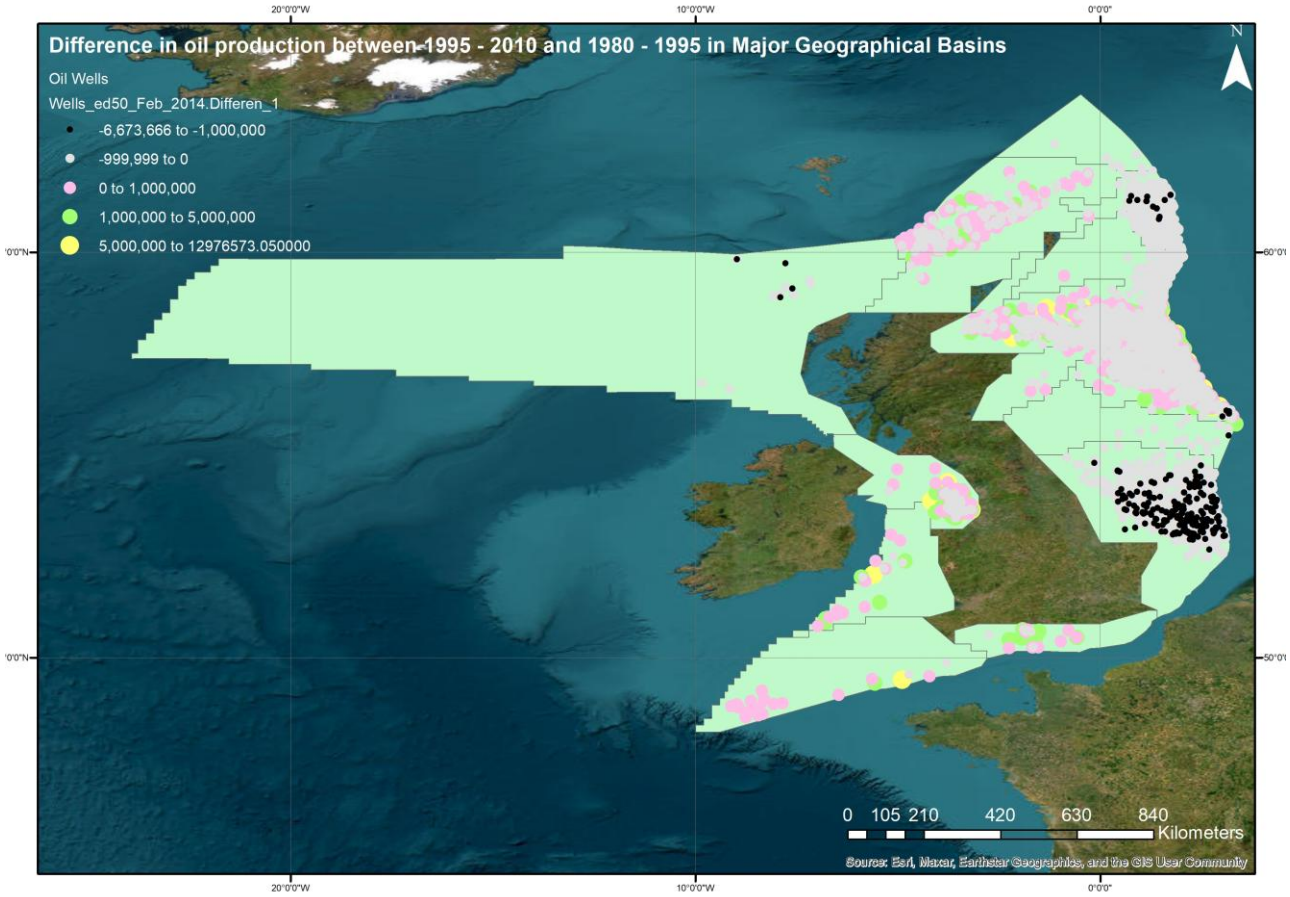


Fig. 12. Difference in oil production for wells present in major geological basins.

9. Comparison of two maps of production change.

The map shown in fig. 13 highlights the oil wells which produced less oil between 1995 to 2010 compared to the period between 1980 to 1995.

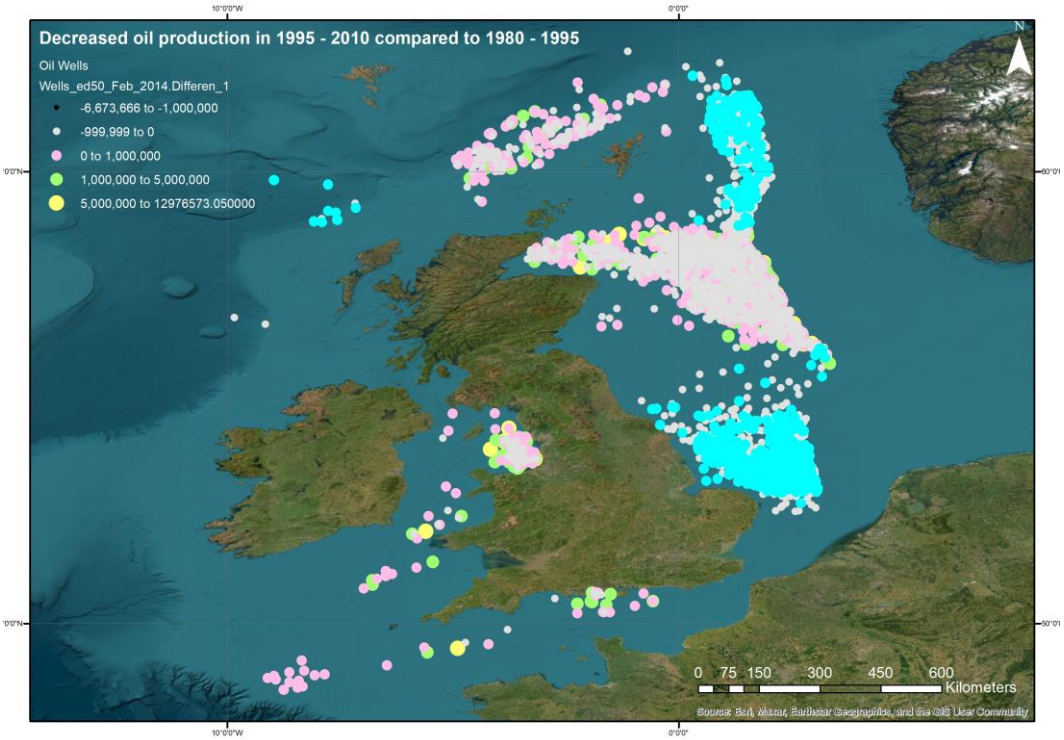


Fig. 13. Wells with decreased oil production between 1995 to 2010.

The map shown in fig. 14 highlights the oil wells which produced more oil between 1995 to 2010 compared to the period between 1980 to 1995.

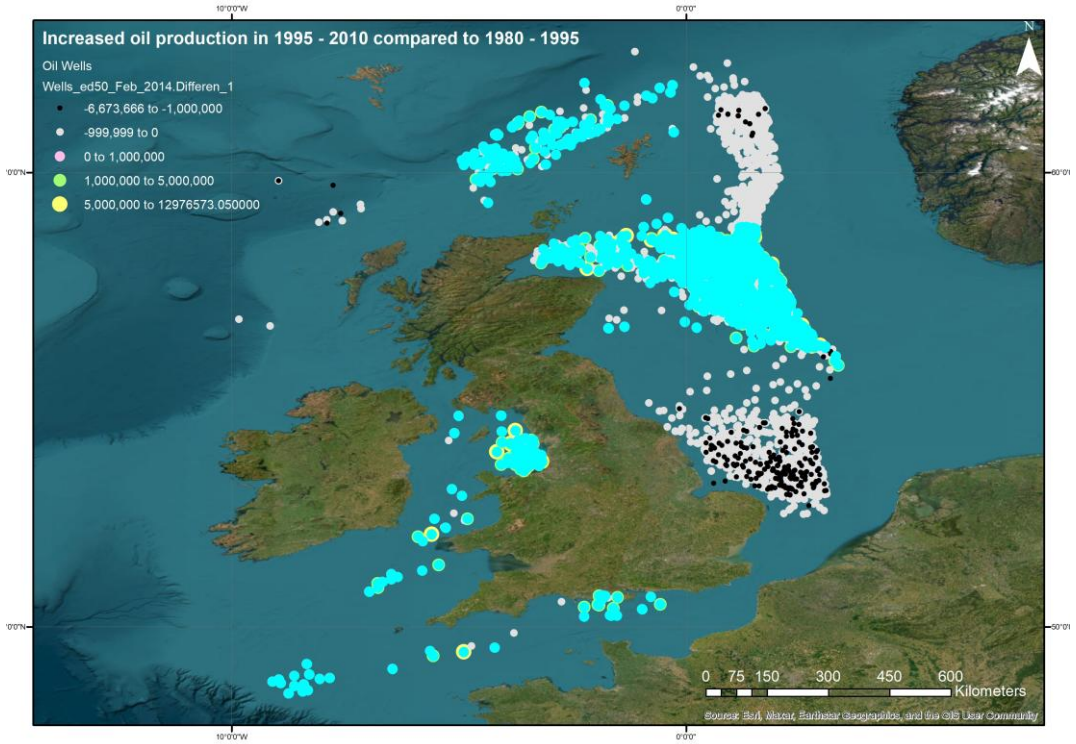


Fig. 14. Wells with increased oil production between 1995 to 2010.

Specifically, when the difference in oil production is viewed with respect to the major geological basins as shown in fig. 12 then it was noticed that West of Shetlands Basin, Moray Forth Basin, Central North Sea Basin, Forth Approaches Basin, Irish Sea Basin, Cardigan Basin, South West Approaches Basin, and Anglo-Paris Basin had experienced increased oil production between 1995 to 2010 compared to 1980 to 1995.

Particularly, the map in fig. 13 shows that the oil wells highlighted have experienced reduction in oil production between 1995 to 2010 compared to the oil production between 1980 to 1995. On the other hand, the map in fig. 14 shows that some of the oil wells highlighted have observed increased oil production in 1995 to 2010 compared to 1980 to 1995 period.

Please refer to the Appendix F for more details about the process.

10. Additional analysis and results.

As the number of oil wells around the UK waters is already known along with their oil outputs, an interpolation technique can be applied to further estimate other possible areas to explore and find oil. One of the interpolation methods is 'Kriging' which uses variogram model to compute weights based on the distribution of known points. In this case, wells located off the

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UK shore becomes points to be used for kriging interpolation. Appendix G details the process involved in applying kriging method.

The map in fig. 15 shows the kriging method being applied to the oil production between 1995 and 2010. The legends on the map shows the range of values in different colours. The regions marked in green shows that there is less than 1.5 million metric tons of oil is estimated in that region, whereas regions marked in brown or white shows that more than 8.5 million metric tons of oil is estimated in the given region. Similarly, fig. 16 shows the map with kriging interpolation applied for the oil production between 1980 and 1995.

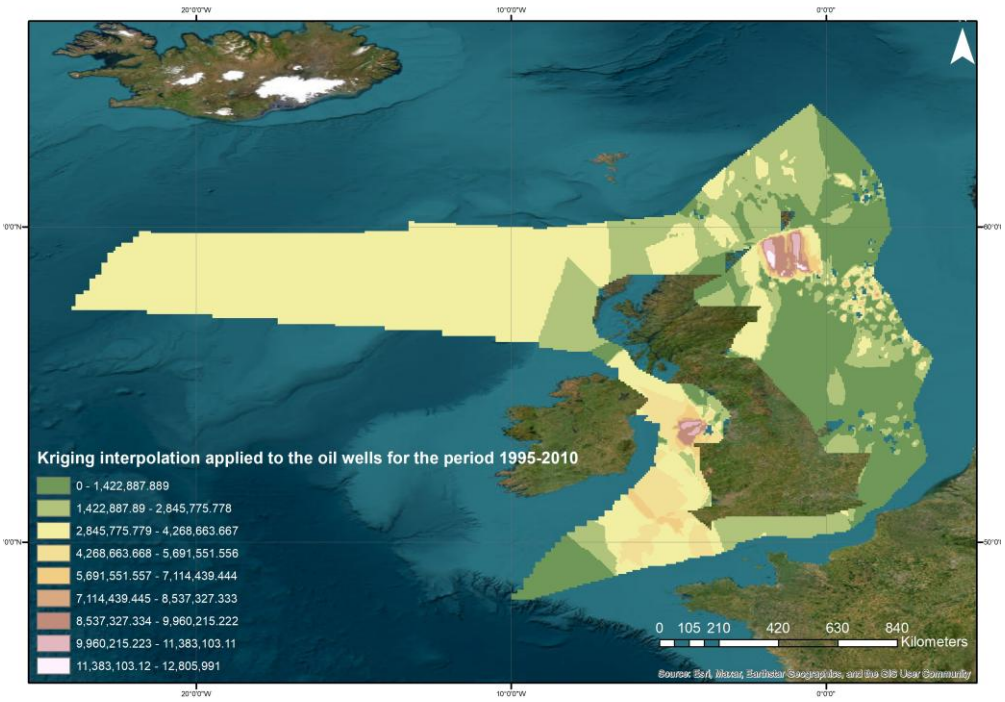

Fig. 15. Kriging interpolation based on oil produced during 1995-2010.

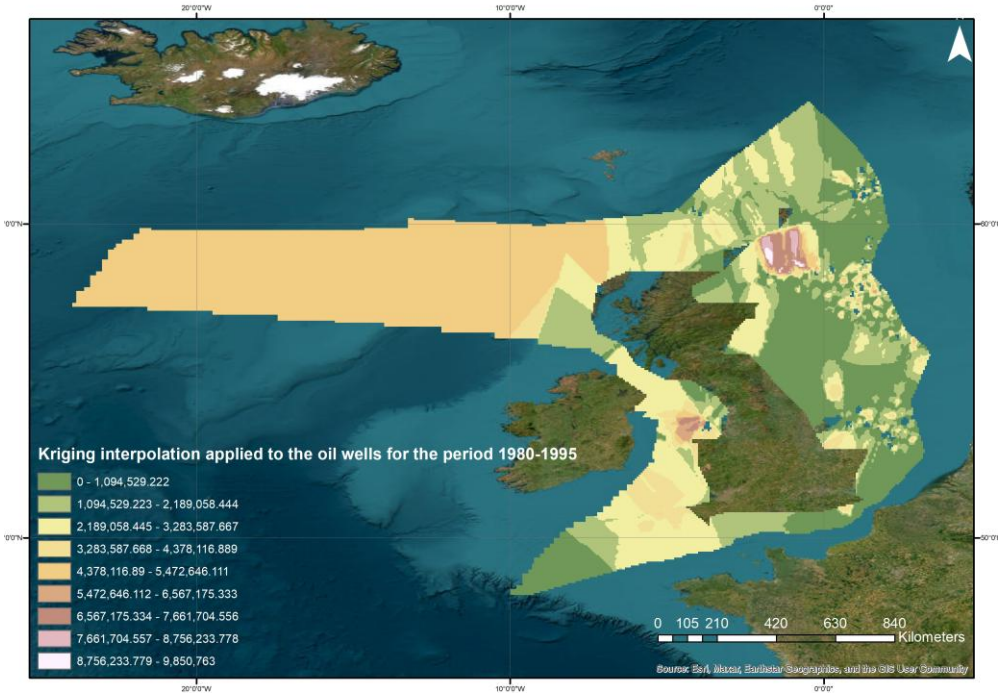

Fig. 16. Kriging interpolation based on oil produced during 1980-1995.

Both the maps shown in fig. 15 and fig. 16 do not look much different visually, but both the kriging raster outputs can be further compared by running differences using Map Algebra to show how much difference in oil production has been realised between both the periods as shown in fig. 17. Refer Appendix G for further details about the application of Map Algebra.

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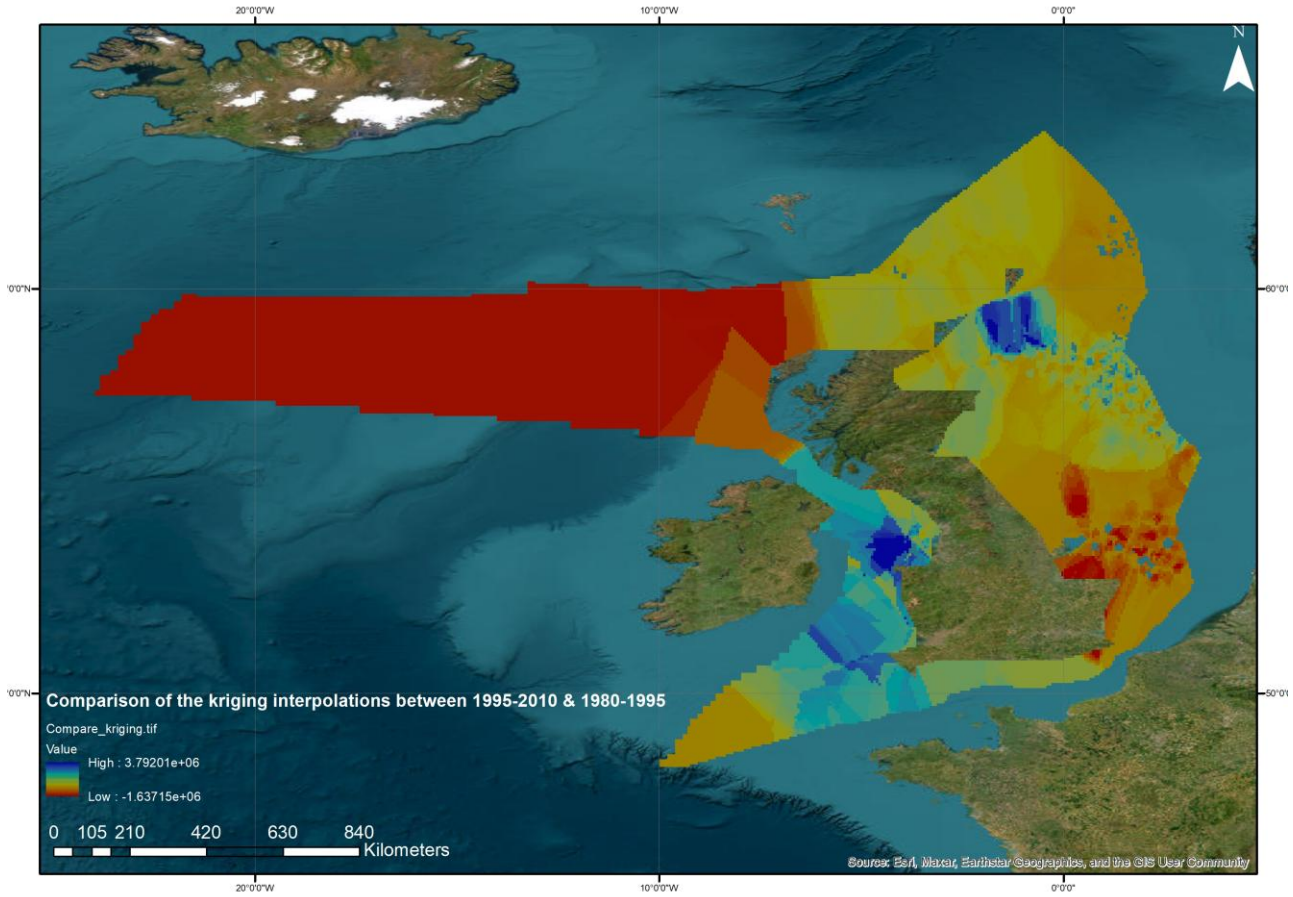


Fig. 17. The comparison between two kriging interpolations between 1995-2010 & 1980-1995.

Conclusion

Reviewing all the tasks performed for the UK oil production study, it is apparent that the oil wells have overall produced less oil during the period of 1995 to 2010 in comparison with oil produced between 1980 and 1995. This was evident from maps and histograms produced earlier in task 7 and 8. However, it is further evident that the area available for oil exploration around the UK is quite large as per the analysis of Geological Basins data available. Thus, it is necessary to identify other possible wells to explore using interpolation techniques.

To identify best location to find new oil fields, oil production data for both the periods were interpolated with kriging interpolation method. The map output of this method was analysed and identified to conclude that offshore locations off the north-east coast of Scotland and Irish sea should be explored further for oil exploration first. The reason to consider these areas first is because the oil wells found in these areas (shown in brown and white colour) have produced more than 8 million metric tons of oil between 1995 – 2010 which was comparatively higher than the oil extracted between 1980 – 1995 period (Refer fig. 15 and 16). Similar findings can be concluded from the comparison map produced by running a difference on two kriging methods.

References

- Essentials of joining tables (2018), ArcMap, ESRI. Available at: https://desktop.arcgis.com/en/arcmap/10.3/manage-data/tables/essentials-of-joining-tables.htm (Accessed: 3rd April, 2023)
- How Kriging Works (2016), ArcMap, ESRI. Available at: https://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/how-kriging-works.htm (Accessed: 07th April, 2023)

Appendices

Appendix A

Methodology followed for the task of joining XLS and Attribute table.

First, 'Data' tab of Wells_production.xls was added in the ArcMap project using 'Add Data' feature as shown in fig. 18.

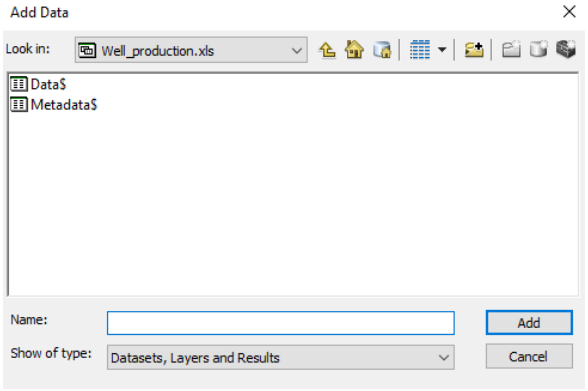


Fig. 18. Adding 'Data' tab from Wells_production.xls to the ArcMap.

Next, 'Join' feature was used from the 'Attribute Table' to join the 'Data' tab with the attribute table (Essentials of joining tables, 2018). Subsequently, selected the column 'WELLREGNO' to join between the attribute table and the 'Data' tab of the spreadsheet as shown in fig. 19.

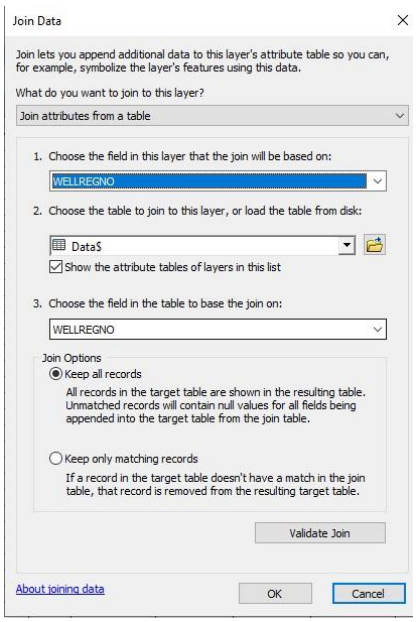


Fig. 19. 'Join Data' wizard of the 'Join' feature to join columns between the attribute table and the spreadsheet.

Appendices

Appendix B

Methodology followed for the task of identifying distribution of wells by geological basin, cartographic quadrant, and water depth.

First, all the quadrants were identified in Quadrants_All.shp layer as shown in fig. 20.

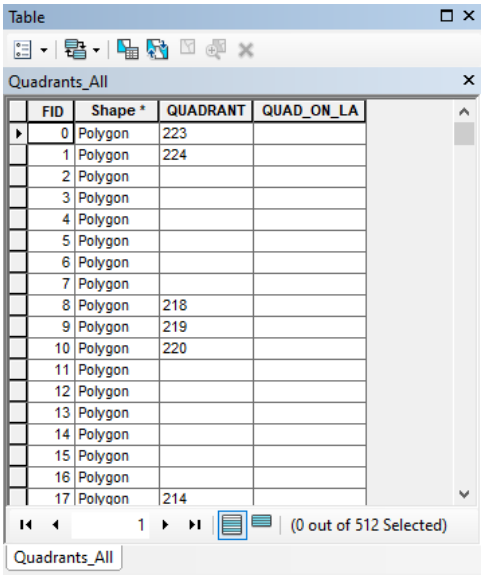


Fig. 20. 512 quadrants present in the attributes table of Quadrants_All.shp layer.

Next, the attribute table of Wells_ed50_Feb_2014.shp file was opened to confirm if there were matching quadrant numbers. Further, statistics were run on 'QUADRANTNO' column to identify which quadrant has maximum number of wells assigned to. Subsequently, query filter to select the wells for that quadrant was applied using WHERE clause "QUADRANTNO" = '211' in 'Select by Attributes' wizard as shown in fig. 21.

Further, mean water depth was identified using statistics option on the WATERDEPTH column in the attribute table of the Wells_ed50_Feb_2014.shp layer. Then, one of the raw was selected and 'identify' tool was used to locate a well to view further details as shown in fig. 22.

Next, 'Geological_Basins_Major' layer was selected along with 'Wells_ed50_Feb_2014' layer to show the wells distribution by the geological basins.

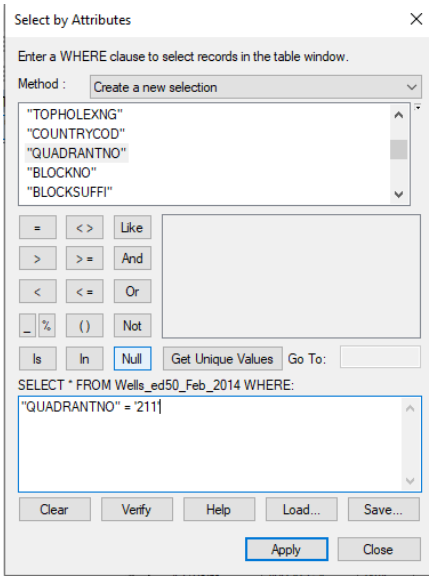


Fig. 21. Query filter applied on QUARDANTNO field using 'Select by Attribute' feature of attribute table.

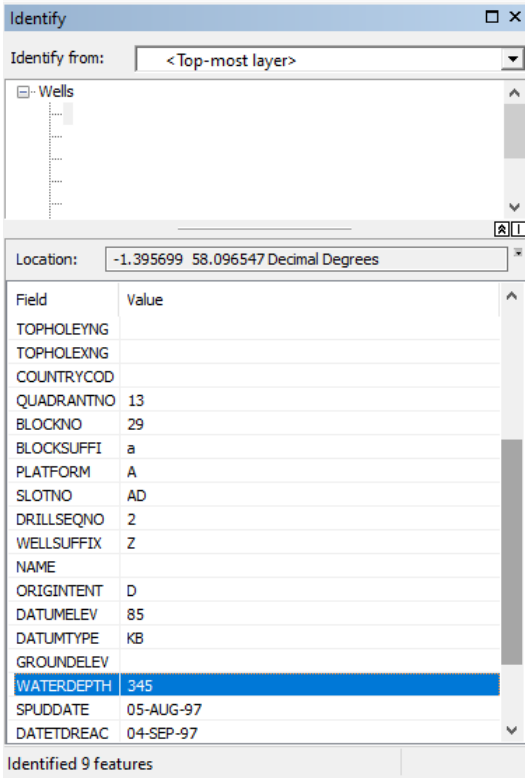


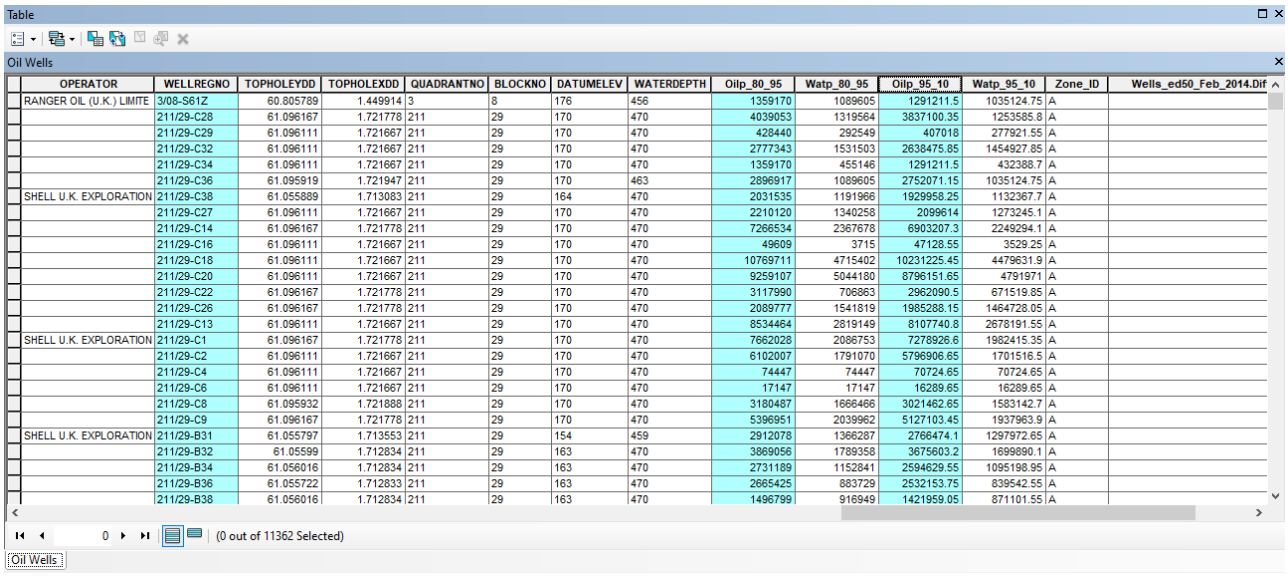
Fig. 22. Wells with 345 meters water depth as shown using 'Identify' dialog box.

Appendices

Appendix C

Methodology followed for the task to identify oil production between 1980 – 1995 and 1995 – 2010

First, all the required fields such as WELLREGNO, Oilp_80_95 and Oilp_95_10 were identified to map the oil production as shown in fig. 23.



OPERATOR	WELLREGNO	TOPHOLEYDD	TOPHOLEXDD	QUADRANTNO	BLOCKNO	DATUMELEV	WATERDEPTH	Oilp_80_95	Watp_80_95	Oilp_95_10	Watp_95_10	Zone_ID	Wells_ed50_Feb_2014.Dif
RANGER OIL (U.K.) LIMITE	3/08-S61Z	60.805789	1.449914	3	8	176	456	1359170	1089605	1291211.5	1035124.75	A	
	211/29-C28	61.096167	1.721778	211	29	170	470	4039053	1319564	3837100.35	1253585.8	A	
	211/29-C29	61.096111	1.721667	211	29	170	470	428440	292549	407018	277921.55	A	
	211/29-C32	61.096111	1.721667	211	29	170	470	2777343	1531503	2638475.85	1454927.85	A	
	211/29-C34	61.096111	1.721667	211	29	170	470	1359170	455146	1291211.5	432388.7	A	
	211/29-C36	61.095919	1.721947	211	29	170	463	2896917	1089605	2752071.15	1035124.75	A	
SHELL U.K. EXPLORATION	211/29-C38	61.055889	1.713083	211	29	164	470	2031535	1191966	1929958.25	1132367.7	A	
	211/29-C27	61.096111	1.721667	211	29	170	470	2210120	1340258	2099614	1273245.1	A	
	211/29-C14	61.096167	1.721778	211	29	170	470	7266534	2367678	6903207.3	2249294.1	A	
	211/29-C16	61.096111	1.721667	211	29	170	470	49609	3715	47128.55	3529.25	A	
	211/29-C18	61.096111	1.721667	211	29	170	470	10769711	4715402	10231225.45	4479631.9	A	
	211/29-C20	61.096111	1.721667	211	29	170	470	9259107	5044180	8796151.65	4791971	A	
	211/29-C22	61.096167	1.721778	211	29	170	470	3117990	706863	2962090.5	671519.85	A	
	211/29-C26	61.096167	1.721778	211	29	170	470	2089777	1541819	1985288.15	1464728.05	A	
	211/29-C13	61.096111	1.721667	211	29	170	470	8534464	2819149	8107740.8	2678191.55	A	
SHELL U.K. EXPLORATION	211/29-C1	61.096167	1.721778	211	29	170	470	7662028	2086753	7278926.6	1982415.35	A	
	211/29-C2	61.096111	1.721667	211	29	170	470	6102007	1791070	5796906.65	1701516.5	A	
	211/29-C4	61.096111	1.721667	211	29	170	470	74447	74447	70724.65	70724.65	A	
	211/29-C6	61.096111	1.721667	211	29	170	470	17147	17147	16289.65	16289.65	A	
	211/29-C8	61.095932	1.721888	211	29	170	470	3180487	1666466	3021462.65	1583142.7	A	
	211/29-C9	61.096167	1.721778	211	29	170	470	5396951	2039962	5127103.45	1937963.9	A	
SHELL U.K. EXPLORATION	211/29-B31	61.055797	1.713553	211	29	154	459	2912078	1366287	2766474.1	1297972.65	A	
	211/29-B32	61.05599	1.712834	211	29	163	470	3869056	1789358	3675603.2	1699890.1	A	
	211/29-B34	61.056016	1.712834	211	29	163	470	2731189	1152841	2594629.55	1095198.95	A	
	211/29-B36	61.055722	1.712833	211	29	163	470	2665425	883729	2532153.75	839542.55	A	
	211/29-B38	61.056016	1.712834	211	29	163	470	1496799	916949	1421959.05	871101.55	A	

Fig. 23. WELLREGNO, Olip_80_95 and Olip_95_10 highlighted in the attribute table of Wells_ed50_Feb_2014.shp.

Next, symbology from the layer properties of the Wells_ed50_Feb_2014.shp was used to classify the Olip_80_95 and Olip_95_10 into four different classes under section 'Graduated Symbols' as shown in fig. 24 and fig. 25.

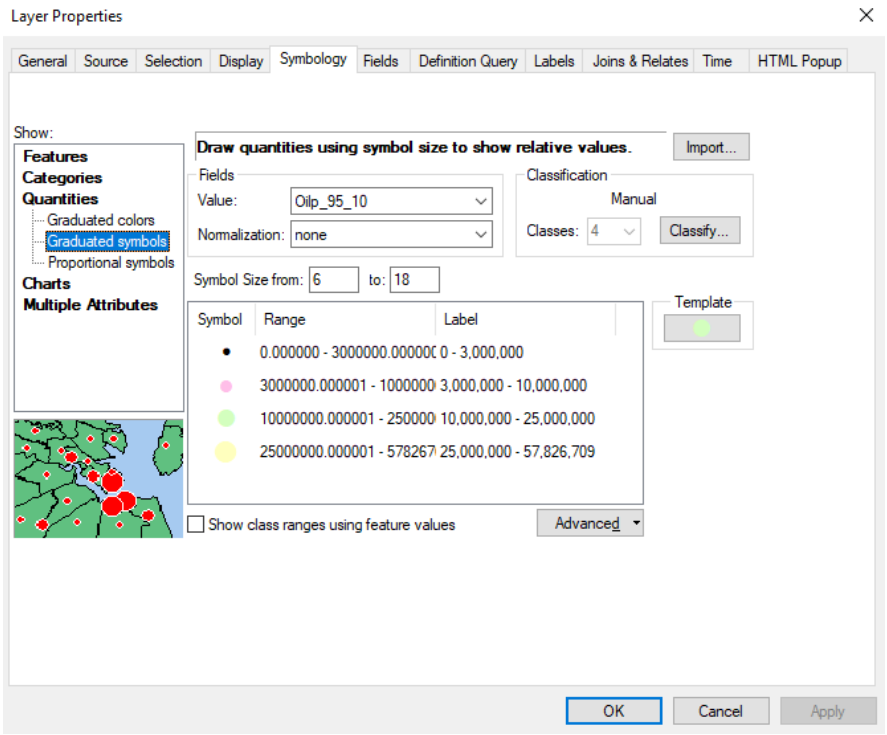


Fig. 24. Symbology tab under layer properties of the Wells_ed50_Feb_2014.shp file.

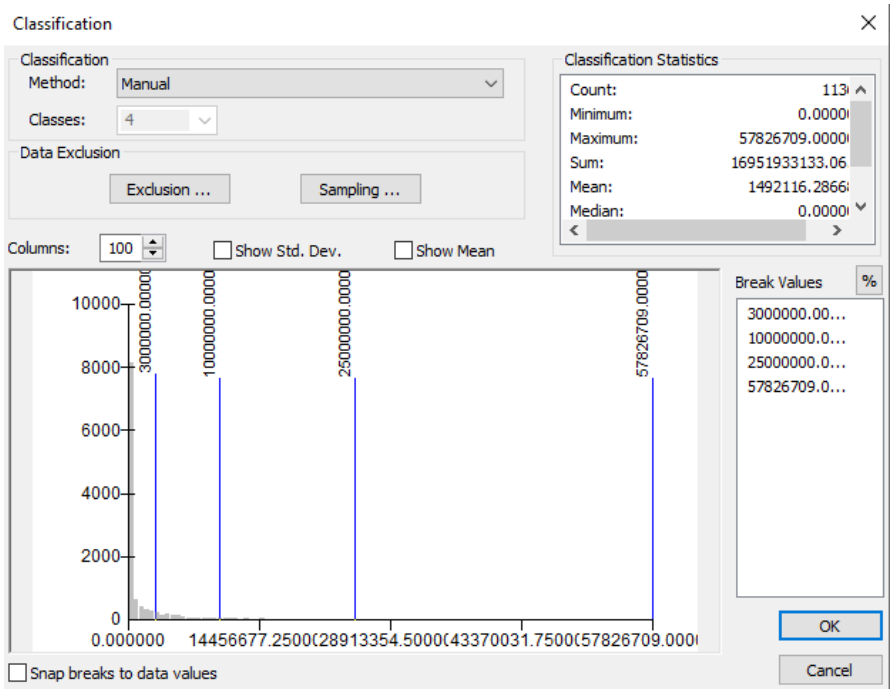


Fig. 25. Classification window showing four break values identified for range of symbols.

Appendices

Appendix D

Methodology followed for quantitative analysis of oil production.

First, the attribute table was analysed to understand the distribution of the oil production values on Olip_80_95. This resulted in finding the fact that 9,849 had wells actually produced less than 3 million metric tons of oil as detailed in 6. Also, Similar analysis was performed on Olip_95_10 as well.

Methodology followed for analysing patterns of change in oil production.

Next, histogram was plotted on the column Oilp_80_95 which more precisely showed that around 11,000 wells had produced just above 12 million metric tons of oil as shown in fig. 26. Similarly, histogram on Olip_95_10 showed that around 11,000 wells had produced just above 11.5 million metric tons of oil as shown in fig. 27.

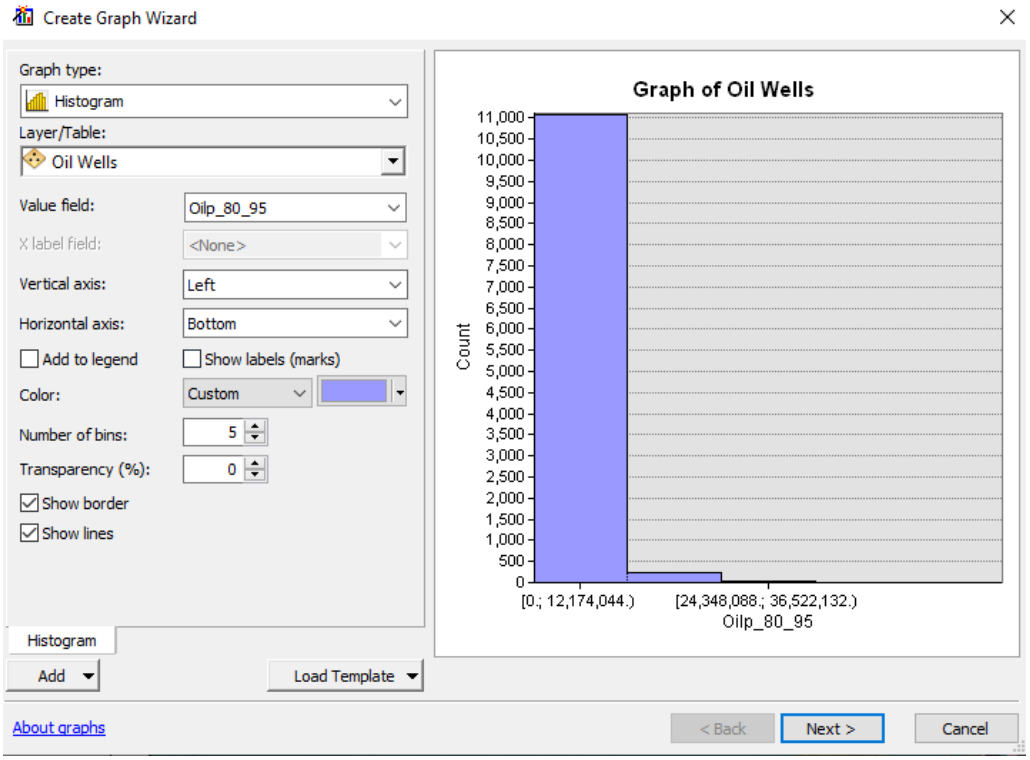


Fig. 26. Histogram applied to Olip_80_95 column on Wells_ed50_Feb_2014 layer.

Appendices

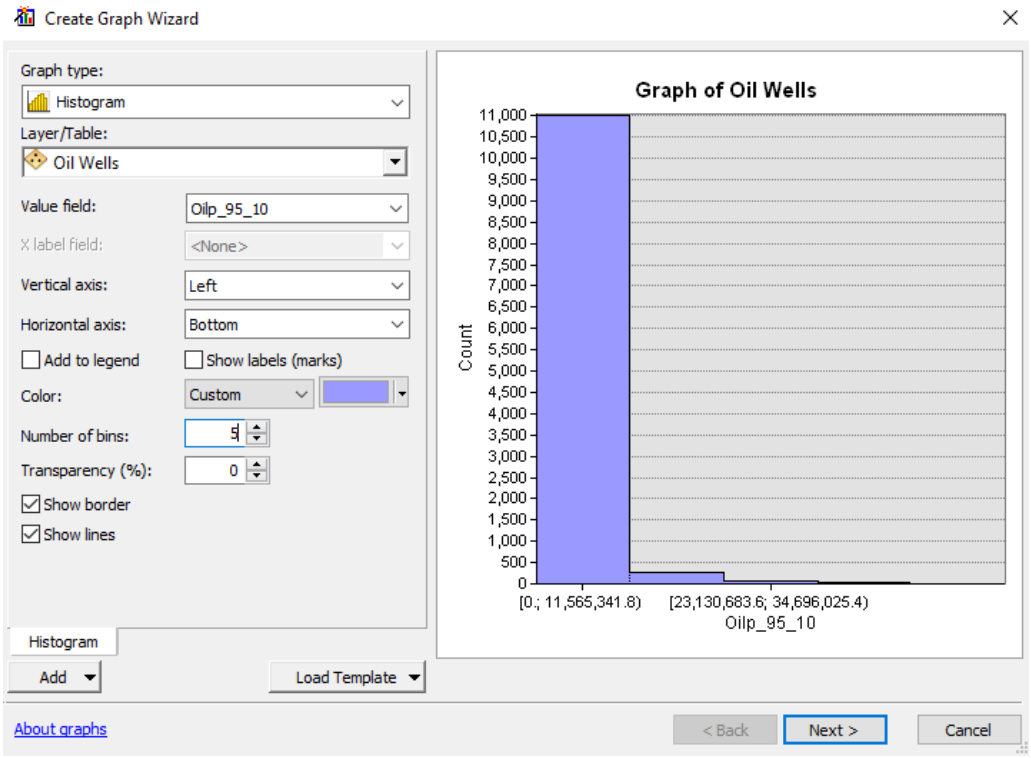


Fig. 27. Histogram applied to Olip_95_10 column on Wells_ed50_Feb_2014 layer.

Appendices

Appendix E

Methodology followed to identify patterns of change in oil production with derived map.

First, new field for difference value was added using 'Add Field' option in the attribute table of Wells_ed50_Feb_2014.shp file.

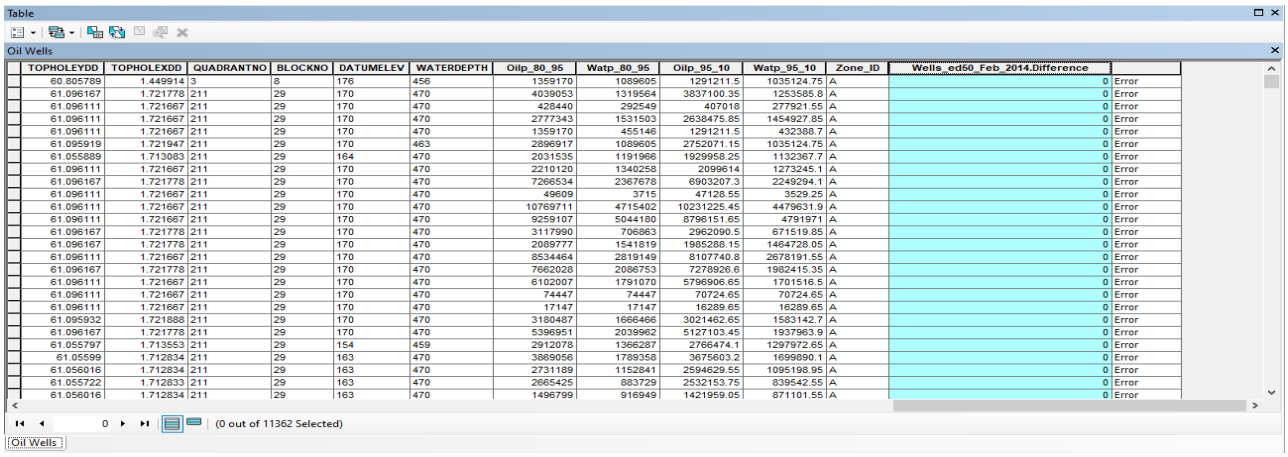


Fig. 28. A field named 'Difference' added to the attribute table of Wells_ed50_Feb_2014.shp layer.

Next, the difference between Olip_95_10 and Olip_80_95 using the field calculator and result was applied to the difference field as shown in fig. 29.

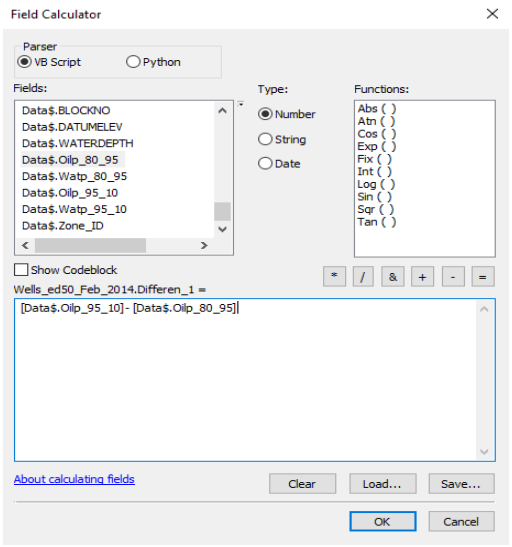


Fig. 29. Using 'Field Calculator' to apply difference between Olip_95_10 and Olip_80_95.

Appendices

Appendix F

Comparison of two maps of production change.

First, maps in fig. 12 and fig. 13 were produced to highlight negative and positive differences using a filter in attribute table to show lower and higher oil productions between the two periods as shown in fig. 30 and fig. 31.

Fig. 30. Select by attributes filter applied to show negative difference between periods.

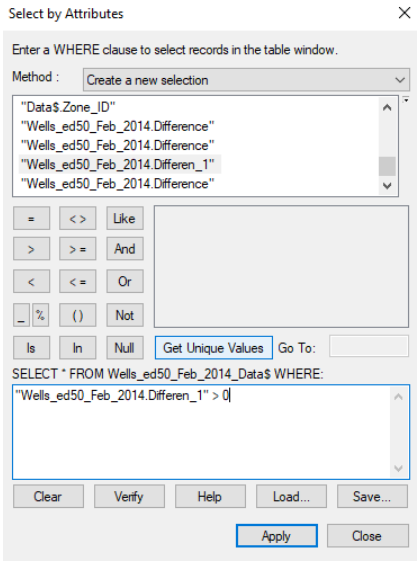


Fig. 31. Select by attributes filter applied to show positive difference between periods.

Appendix G

Methodology applied for additional analysis and results.

First, kriging tool under Spatial Analyst was opened. It was then supplied with input feature as Wells_ed50_Feb_2014.shp, and Z value field as Olip_80_95 and Olip_95_10 for generating two separate raster outputs as shown in fig. 32. Further, environment variables were set to apply processing extent and mask for raster analysis as shown in fig. 33 below (How Kriging Works, 2016). Further, a raster calculator was applied on two raster outputs to calculate the difference and plot it on a map as shown in fig. 34.

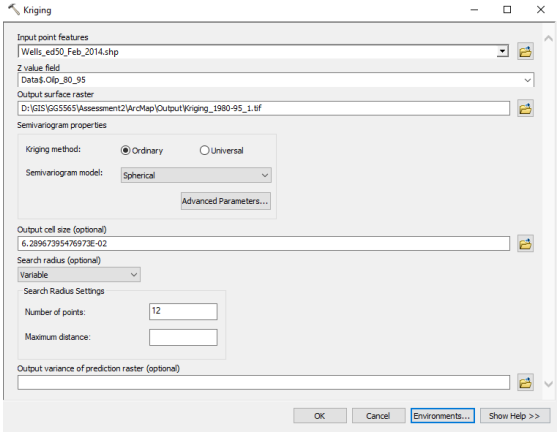


Fig. 32. Kriging method applied to Wells_ed50_Feb_2014.shp on Olip_80_95 field.

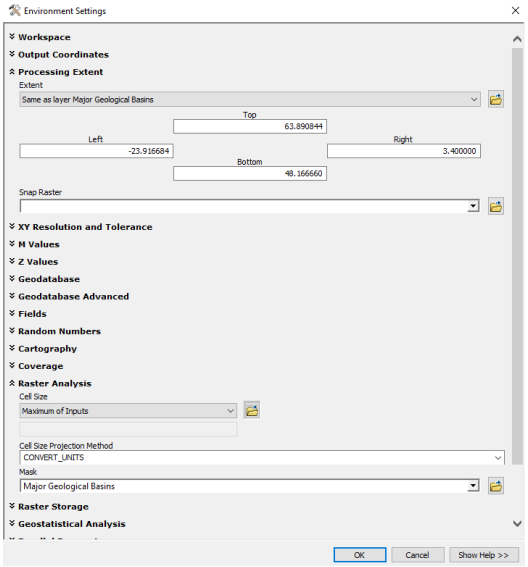


Fig. 33. Environmental settings applied to set 'Processing Extent' and 'Raster Analysis'.

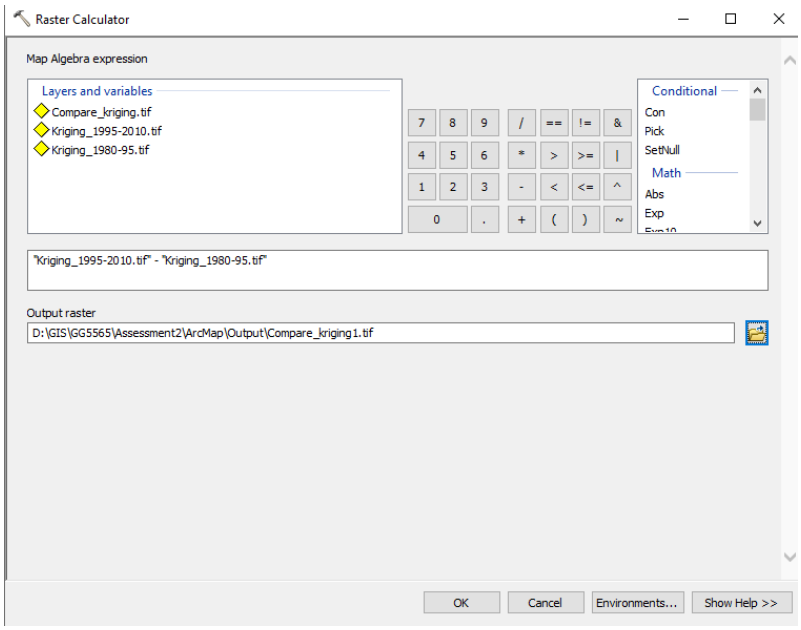


Fig. 34. Application of Raster Calculator to find difference between two kriging output.