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Title: Ecological Encroachment and it Environmental Implications in Badegana Grazing Reserve of Northeastern Nigeria

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Abstract: *Studies on ecological encroachment in grazing reserves through spatial analysis represent vital evidence for comprehensive decision making on resources management. This study aimed to evaluate ecological encroachment and it environmental implications in grazing reserves of Northeastern Nigeria. The method used were spatial analysis, field inventory and observations. Base on the major findings, there are evidence of encroachment due to cultivated land increases from 53% to 84% and bareground stands at 7%. Grassland decreases from 36% to 4% and forest cover stands at 4% with changes to 6% between 2005 and 2010. Later, cultivated land decreases to less than 1% (Plate 1) and bareground increases from 7% to 34%. Grassland increase to 93% and further decrease to 65%, while forest cover increase to 1% in 2015 to 2020. In conclusion, the research work established the efficacy of satellite remote sensing imagery of LU cover records and changes in Badegana Gazing Reserve for the past 15 years. It can be deduced that; encroachment due to cultivation reduces across the period from 2005 to 2020. In the long run, the reserve is sustainable for livestock grazing since there is drastic reduction on cultivated land.*
Keywords: Ecological; Encroachment; Environmental Implications; Grazing Reserve; Nigeria

1. Introduction

Nigeria is among the countries witnessing rapid population growth in the world, quadrupling from 30.4 million people in 1952 to 193.3 million people in 2016 (National Bureau of Statistics, 2017). As the population is increasing, the Northeastern zone of Nigeria is experiencing environmental changes, leading to increasing aridity and degradation (Abdulkadir *et al.*, 2013). This leads to resource over-exploitation, ecological degradation and ultimately loss of habitats and biodiversity (Olalekan *et al.* 2019). These have created increased demand for land, particularly for the most productive fields resulting to sustained competition and subsequently ecological encroachment.

Increasing human activities such as agriculture and settlement development have exerted so many tolls on the ecosystem of grazing reserve's and has resulted in the loss of great proportion of vegetation (Teka *et al.* 2018 and Pfeiffer *et al.* 2019). Most grazing reserves and routes disappeared due to increasing settlements and cropping intensity. These are due to improper implementation of legal instrument to prevent encroachments (Ahmed *et al*. 2002).

Ecosystem degradation is commonly assessed based on vegetation conditions leading to different land types (grassland, forest, bareground and cultivated land) (Teka *et al.* 2018 and Sato *et al.* 2019). Remote sensing technology and GIS provide efficient methods for analysis of vegetation cover issues and tool for landuse planning (Cook and Pau, 2013). By understanding the driving force of landuse development in the past, managing current situation with modern GIS tools, for future use, one is able to develop plans for multiple uses of natural resources for conservation.

Both natural and anthropogenic pressures are sources of continuous threat on grazing reserves in Nigeria and herders are among the people who are mostly affected (Chhabra *et al.* 2006 and Muhammad *et al.* 2019). Herders' approach over management of grazing lands consists of mobility of herds; strong community norms and regulations on pasture and water resource use (Angassa and Oba, 2008).

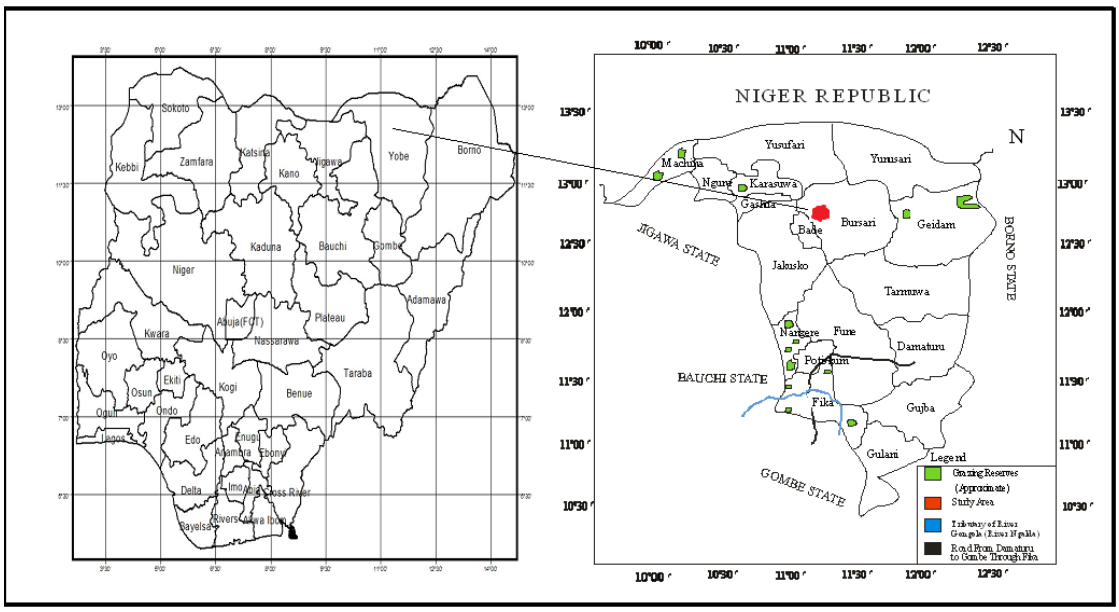
Due to the fact that there are increasing wave of encroachment into grazing reserves in Northeastern Nigeria, this study aimed to evaluate ecological encroachment and environmental implications of Grazing Reserves in Northeastern Nigeria for the period of 15 years (2005-2020). It is conceived with a view to examine Land Use/ Land Cover (LULC), evaluate herders' attribute on Land Cover (LC) changes and draw environmental implications for the study area.

2. Materials and Methods

2.1 Study Area

Badegana Grazing Reserve is located between latitude 12°34′30″ to 12°42′00″ N and longitude 11°18′00″ to 11°27′10″ E. It is situated in Sahellian Region of Northeastern Nigeria in Yobe State (Figure 1). The area is found in Bursari Local Government Area and covers an area of 190 km^2

(The Grazing Reserves Law, 1965). The estimated population of the state is over 3.2 million in 2016 (National Bureau of Statistics, 2017).



Source: Department of Environmental Management, BUK (2020).
Figure 1: Study Area

2.2 Methods

2.2.1 Spatial analysis

Three different data types were obtained for the classification of the grazing reserves. Landsat data was collected from United States Geological Survey (USGS), an open-source repository of satellite images and their metadata downloaded (Appendix I). Four Landsat imageries were collected for Badegana Grazing Reserve. A total of four satellite imageries were collected. This was to cover for 2005, 2010, 2015 and 2020 respectively. A high resolution 0.3 meters pixel satellite images from google maps for the individual year were also obtained. Coordinates of the boundaries covering the grazing reserve was also obtained (Yobe State Ministry of Land and Survey, 2020). The imageries were carefully selected for the study to avoid cloud covers or at most minimum cloud covers.

i. **Data Processing:** The imageries were extracted from the zip folder within which they were compressed into single band imageries. The 2005 and 2010 imageries are Landsat 7 imageries while the 2015 and 2020 imageries are Landsat 8 imageries. Bands 2, 3, 4, 5, 6 and 7 were selected for Landsat 7 while band 8 was included for Landsat 8. The Landsat toolbox in

ArcGIS was utilized to remove scan lines for all the bands in Landsat 7. The composite band tool, an extension of ArcGIS data management tool was used to create composite bands. The google images for each year were georeferenced using the ArcGIS georeferencing tool to ensure their exact position on the globe.

ii. **Land Cover Classification:** A folder was created and the composite bands raster for the reserve was inserted. The obtained coordinates for the reserve was converted to a polygon using the point to polygon tool in ArcGIS. This is superimposed with the composite band raster and the google satellite images. The classification tool in ArcGIS was used to classify the various land covers for the grazing reserve. A supervised classification was used for this analysis to ensure better accuracy of the different land activities in the reserve. Grassland, forest, cultivated land and bareground were classified respectively.

2.2.2 Field Inventory

Field inventory and observations were conducted. Ten herders participated for the land cover changes attribute from 2005 to 2020 of Badegana grazing reserve.

3. Result and Discussion

3.1 Land Classification and Change of Badegana Grazing Reserve

The result of the analyses of the trends in landuse and landcover changes of Badegana grazing reserve at period of 2005, 2010, 2015 and 2020 is presented in Table 1. The result reveals that there are four LULC classes; grassland, forest, cultivated land and bareground (Figure 2). Each of these classes was attributed to different changes between 2005 and 2020 which can be deduced in Table 2 from responses of herders in the grazing reserve.

LULC map shows changes in 2005 to 2010, encroachment due to cultivated land increases from 53% to 84% and bareground stands at 7%. Grassland decreases from 36% to 4% and forest cover stands at 4% with changes to 6% at that period. These decrease in grassland and increase in cultivated land was attributed in Table 2 by herders the grazing reserve was used for cultivation by Yobe State Government Ministry of Agriculture and Rural Development to engage and empower rural masses in the area to reduce poverty for the period of three years.

In Badegana grazing reserve there are changes between 2015 and 2020, cultivated land decreases to less than 1% (Plate 1) and bareground increases from 7% to 34%. Grassland increase to 93% and further decrease to 65%, while forest cover increase to 1% at that period. Decrease in grassland and increase in bareground was attributed to (Table 2) overstocking of the grazing reserve by migratory herders' insecurity due to terrorist activities in Dapchi town which leads to kidnapping of school girls' by Islamic State West African Province (ISWAP).

Table 1: Classification of LU/LC in Badegana Grazing Reserve

Land Type	2005		2010		2015		2020	
	km²	%	km²	%	km²	%	km²	%
Grassland	67.6694	36	6.8906	4	176.0796	93	123.7385	65
Forest	0.0009	4	0.0027	6	0.0011	0	1.3284	1
Bareground	13.374	7	12.5127	7	13.7961	7	64.2033	34
Cultivated land	108.9567	53	170.595	84	0.1242	0	0.7308	0
Total	190.001	100	190.001	100	190.001	100	190.001	100

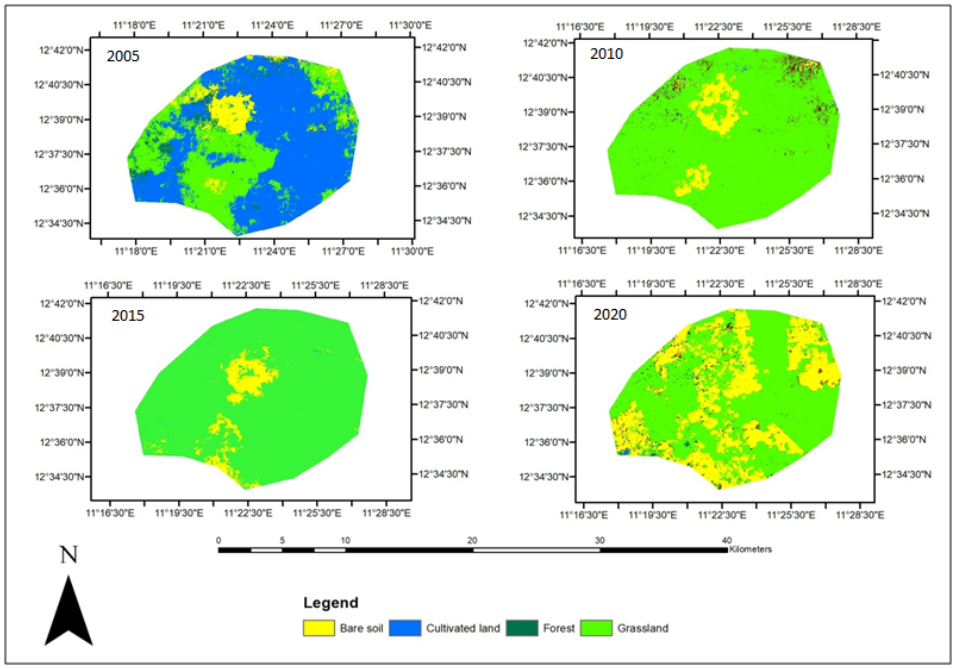


Figure 2: Extracted and Classified Satellite Imagery of Badegana Grazing Reserve

Source: Fieldwork, (2021).
Plate 1: Cultivated Land in Badegana Grazing Reserve

Table 2: Herders' Attribute towards LC Changes from 2005-2020

S/No	Attribute of Change	% Respondents			
		2005	2010	2015	2020
1	Rainfall variability	-	1	8	4
2	Over stocking	-	6	5	20
3	Indiscriminate bush fires	12	7	10	2
4	Settlement/Built up	-	-	-	-
5	Lack of watering points	18	2	10	6
6	Insecurity due to terrorist activities	-	-	61	58
7	Farming intensification	70	84	6	10
Total		100	100	100	100

Source: Fieldwork, (2021).

3.2 Environmental Implications

According to National Economic Council (2019), the Federal Government came up with National Livestock Transformation Plan (NLTP) as a policy aimed at three prolonged approach outlines to: Provides a roadmap for modernizing livestock production using a mix of nomadic breeding and ranching that would serve a modernized dairy and beef processing industry; Develops a plan for resetting and addressing the dislocated populations in the key conflict zones to enable them become a part of the agriculture modernization process; and Provides a mechanism for peaceful dialogue and reconciliation in the affected communities towards a harmonious multi-cultural interdependent mutual beneficial future (National Economic Council, 2019). The NLTP if fully implemented will help to cater the problems of encroachment into Badegana Grazing Reserve due

to farming intensification and shift in cropland, bush fires. The landuse/ land cover for the period of 2005 to 2020, shows that cultivated land and settlements were slowly reducing to give space for grazing.

Most grazing reserves were attributed to impact of encroachment due to lack of long time planning from the government agencies responsible for management of the grazing reserves (Anene and Iyala, 2020). Notwithstanding, ecosystem degradation is commonly assessed based on vegetation conditions leading to different land types (grassland, forest, bareground, cultivated land and built up) (Teka *et al.* 2018 and Sato *et al*. 2019). Based on the findings in landuse/ land cover changes of the grazing reserves for the period of 2005 to 2020, encroachment due to cultivated land were revealed in the grazing reserve. Cultivated land was rated with more than 53% during 2005, 84% in 2010 and slowly reducing during 2015 and 2020 to less than 1% (Table 1). Thus, if this encroachment due to cultivated land slowly reduces, this will result to a total recovery of the grazing environment by vegetation cover.

The expansion of cultivated land in the grazing reserve has affected fodder production for livestock. Voluntary cultivation have been established in the grazing reserve (Figure 2) (Plate 1) for generating income and livelihood diversification. Hence, these reduce the size of the grazing reserve and mobility to utilize the unevenly distributed resources in the environment. Thus, if this situation continuous it results in destruction of important fodder crop, land degradation and soil infertility.

4. Conclusion

So long as vital facts on LULC changes is used to comprehend land characteristic and monitoring resources over time. Gathering significant evidences on such changes may perhaps give insights to policy makers with decision over sustainable livestock grazing system with proper support. The research work established the efficacy of satellite remote sensing imagery of LU cover records and changes in Badegana Gazing Reserve for the past 15 years. It can be deduced that; encroachment

due to cultivation reduces across the period from 2005 to 2020. In the long run, the reserve is sustainable for livestock grazing since there is drastic reduction on cultivated land.

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Appendix

Badegana 2020 Metadata

LC08_L1TP_187051_20200225_20200313_01_T1

Field	Value
Landsat Product Identifier	LC08_L1TP_187051_20200225_20200313_01_T1
Landsat Scene Identifier	LC81870512020056LGN00
Acquisition Date	2020/02/25
Collection Category	T1
Collection Number	1
WRS Path	187
WRS Row	051
Target WRS Path	187
Target WRS Row	051
Nadir/Off Nadir	NADIR
Roll Angle	-0.001
Date L-1 Generated	2020/03/13
Start Time	2020:056:09:36:20.8672730
Stop Time	2020:056:09:36:52.6372720
Station Identifier	LGN
Day/Night Indicator	DAY
Land Cloud Cover	26.36
Scene Cloud Cover	26.36
Ground Control Points Model	466
Ground Control Points Version	4
Geometric RMSE Model (meters)	8.091
Geometric RMSE Model X	6.276
Geometric RMSE Model Y	5.106
Image Quality	9
Processing Software Version	LPGS_13.1.0
Sun Elevation L1	54.17382553
Sun Azimuth L1	126.95002306
TIRS SSM Model	FINAL
Data Type Level-1	OLI_TIRS_L1TP
Sensor Identifier	OLI_TIRS
Panchromatic Lines	15441
Panchromatic Samples	15121
Reflective Lines	7721
Reflective Samples	7561
Thermal Lines	7721
Thermal Samples	7561
Map Projection Level-1	UTM
UTM Zone	32
Datum	WGS84
Ellipsoid	WGS84
Grid Cell Size Panchromatic	15.00
Grid Cell Size Reflective	30.00
Grid Cell Size Thermal	30.00
Bias Parameter File Name	OLILO8BPF20200225091939_20200225105656.01
Bias Parameter File Name	TIRSLT8BPF20200223110021_20200310034739.01
Calibration Parameter File	LC08CPF_20200101_20200331_01.04
RLUT File Name	LC08RLUT_20150303_20431231_01_12.h5
Center Latitude	13°00'44.75"N
Center Longitude	10°50'45.74"E
UL Corner Lat	14°03'25.13"N
UL Corner Long	10°10'34.72"E
UR Corner Lat	13°41'43.84"N
UR Corner Long	11°53'45.13"E

LL Corner Lat	12°19'19.99"N
LL Corner Long	9°48'02.81"E
LR Corner Lat	11°57'29.99"N
LR Corner Long	11°30'29.09"E
Center Latitude dec	13.01243
Center Longitude dec	10.84604
UL Corner Lat dec	14.05698
UL Corner Long dec	10.17631
UR Corner Lat dec	13.69551
UR Corner Long dec	11.89587
LL Corner Lat dec	12.32222
LL Corner Long dec	9.80078
LR Corner Lat dec	11.95833
LR Corner Long dec	11.50808

Badegana 2015 Metadata

LC08_L1TP_187051_20150315_20170412_01_T1

Field	Value
Landsat Product Identifier	LC08_L1TP_187051_20150315_20170412_01_T1
Landsat Scene Identifier	LC81870512015074LGN01
Acquisition Date	2015/03/15
Collection Category	T1
Collection Number	1
WRS Path	187
WRS Row	051
Target WRS Path	187
Target WRS Row	051
Nadir/Off Nadir	NADIR
Roll Angle	-0.001
Date L-1 Generated	2017/04/12
Start Time	2015:074:09:35:57.2869220
Stop Time	2015:074:09:36:29.0569180
Station Identifier	LGN
Day/Night Indicator	DAY
Land Cloud Cover	4.39
Scene Cloud Cover	4.39
Ground Control Points Model	519
Ground Control Points Version	4
Geometric RMSE Model (meters)	7.072
Geometric RMSE Model X	5.416
Geometric RMSE Model Y	4.549
Image Quality	9
Processing Software Version	LPGS_2.7.0
Sun Elevation L1	58.87771108
Sun Azimuth L1	117.30872242
TIRS SSM Model	ACTUAL
Data Type Level-1	OLI_TIRS_L1TP
Sensor Identifier	OLI_TIRS
Panchromatic Lines	15441
Panchromatic Samples	15101
Reflective Lines	7721
Reflective Samples	7551
Thermal Lines	7721
Thermal Samples	7551
Map Projection Level-1	UTM
UTM Zone	32
Datum	WGS84
Ellipsoid	WGS84
Grid Cell Size Panchromatic	15.00
Grid Cell Size Reflective	30.00
Grid Cell Size Thermal	30.00
Bias Parameter File Name OLI	LO8BPF20150315082413_20150315100306.02
Bias Parameter File Name TIRS	LT8BPF20150315082506_20150315100359.07
Calibration Parameter File	LC08CPF_20150302_20150331_01.01
RLUT File Name	LC08RLUT_20150303_20431231_01_12.h5
Center Latitude	13°00'44.57"N
Center Longitude	10°50'22.60"E
UL Corner Lat	14°03'24.66"N
UL Corner Long	10°10'10.16"E
UR Corner Lat	13°41'43.44"N
UR Corner Long	11°53'22.74"E
LL Corner Lat	12°19'20.17"N
LL Corner Long	9°47'38.90"E
LR Corner Lat	11°57'30.20"N
LR Corner Long	11°30'07.38"E
Center Latitude dec	13.01238
Center Longitude dec	10.83961
UL Corner Lat dec	14.05685
UL Corner Long dec	10.16949
UR Corner Lat dec	13.69540
UR Corner Long dec	11.88965
LL Corner Lat dec	12.32227
LL Corner Long dec	9.79414
LR Corner Lat dec	11.95839
LR Corner Long dec	11.50205

Badegana 2010 Metadata

LE07_L1TP_187051_20100221_20161215_01_T1

Field	Value
Landsat Product Identifier	LE07_L1TP_187051_20100221_20161215_01_T1
Landsat Scene Identifier	LE71870512010052ASN00
Acquisition Date	2010/02/21

Scan Line Corrector	OFF
Collection Category	T1
Collection Number	1
Sensor Mode	BUMPER
WRS Path	187
WRS Row	051
Date L-1 Generated	2016/12/15
Start Time	2010:052:09:28:22.4086874
Stop Time	2010:052:09:28:49.1627500
Station Identifier	ASN
Day/Night Indicator	Day
Land Cloud Cover	0.00
Scene Cloud Cover	0.00
Ground Control Points Model	126
Ground Control Points Version	4
Geometric RMSE Model (meters)	4.517
Geometric RMSE Model X	2.922
Geometric RMSE Model Y	3.444
Image Quality	9
Gain Change	N
Processing Software Version	LPGS_12.8.2
Full Partial Scene	FULL
Sun Elevation L-1	51.65261676
Sun Azimuth L-1	126.46933656
Gap Phase Source	DE
Gap Phase Statistic	10.875499
Data Type Level-1	ETM_L1TP
Sensor Identifier	ETM
Ephemeris Type	DEFINITIVE
Panchromatic Lines	13821
Panchromatic Samples	15881
Reflective Lines	6911
Reflective Samples	7941
Thermal Lines	6911
Thermal Samples	7941
Map Projection Level-1	UTM
UTM Zone	32
Datum	WGS84
Ellipsoid	WGS84
Grid Cell Size Panchromatic	15.00
Grid Cell Size Reflective	30.00
Grid Cell Size Thermal	30.00
Calibration Parameter File	LE07CPF_20100101_20100331_01.02
Scan Gap Interpolation	2.0
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UL Corner Lat	13°56'27.49"N
UL Corner Long	10°04'30.97"E
UR Corner Lat	13°41'15.72"N
UR Corner Long	11°49'06.89"E
LL Corner Lat	12°19'26.90"N
LL Corner Long	9°43'30.54"E
LR Corner Lat	12°04'20.82"N
LR Corner Long	11°27'26.75"E
Center Latitude dec	13.00828
Center Longitude dec	10.76925
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UL Corner Long dec	10.07527
UR Corner Lat dec	13.68770
UR Corner Long dec	11.81858
LL Corner Lat dec	12.32414
LL Corner Long dec	9.72515
LR Corner Lat dec	12.07245
LR Corner Long dec	11.45743

Badegana 2005 Metadata

LE07_L1TP_187051_20050412_20170115_01_T1

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Acquisition Date	2005/04/12
Scan Line Corrector	OFF
Collection Category	T1
Collection Number	1
Sensor Mode	
WRS Path	187
WRS Row	051
Date L-1 Generated	2017/01/15
Start Time	2005:102:09:25:58.9808750
Stop Time	2005:102:09:26:26.1687499
Station Identifier	EDC
Day/Night Indicator	Day
Land Cloud Cover	2.00
Scene Cloud Cover	2.00
Ground Control Points Model	103
Ground Control Points Version	4
Geometric RMSE Model (meters)	6.465
Geometric RMSE Model X	3.353
Geometric RMSE Model Y	5.528
Image Quality	9
Gain Change	N
Processing Software Version	LPGS_12.8.3
Full Partial Scene	FULL
Sun Elevation L-1	62.31681814
Sun Azimuth L-1	95.85975388
Gap Phase Source	DE
Gap Phase Statistic	10.430324
Data Type Level-1	ETM_L1TP
Sensor Identifier	ETM

Ephemeris Type	DEFINITIVE
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Panchromatic Samples	15561
Reflective Lines	7001
Reflective Samples	7781
Thermal Lines	7001
Thermal Samples	7781
Map Projection Level-1	UTM
UTM Zone	32
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Ellipsoid	WGS84
Grid Cell Size Panchromatic	15.00
Grid Cell Size Reflective	30.00
Grid Cell Size Thermal	30.00
Calibration Parameter File	LE07CPF_20050401_20050630_01.02
Scan Gap Interpolation	2.0
Center Latitude	12°58'50.88"N
Center Longitude	10°46'08.04"E

UL Corner Lat	13°55'45.48"N
UL Corner Long	10°04'39.36"E
UR Corner Lat	13°40'34.32"N
UR Corner Long	11°49'17.40"E
LL Corner Lat	12°17'09.24"N
LL Corner Long	9°43'21.72"E
LR Corner Lat	12°02'04.20"N
LR Corner Long	11°27'19.80"E
Center Latitude dec	12.98080
Center Longitude dec	10.76890
UL Corner Lat dec	13.92930
UL Corner Long dec	10.07760
UR Corner Lat dec	13.67620
UR Corner Long dec	11.82150
LL Corner Lat dec	12.28590
LL Corner Long dec	9.72270
LR Corner Lat dec	12.03450
LR Corner Long dec	11.45550