Course Project - ETL & Batch Processing

Problem Statement

Ingest the India Annual Health Survey (AHS) 2012-13 data hosted on Amazon RDS into Hadoop correctly and process it to generate the following analyses:

Analyses

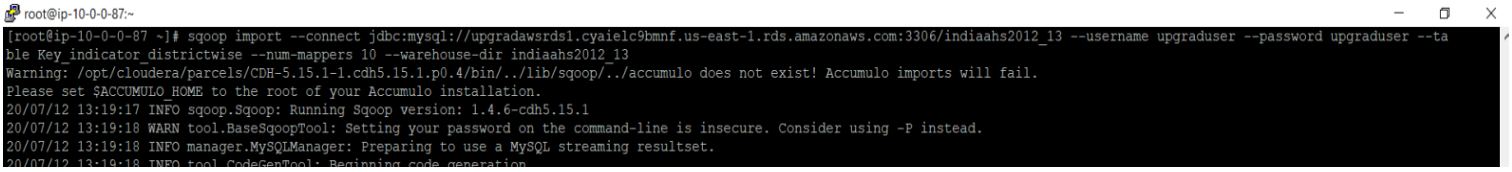
- *The child mortality rate in Uttar Pradesh*
- *The fertility rate in Bihar*
- *State-wise child mortality rate and state-wise fertility rate and does high fertility correlate with high child mortality?*
- *Find top 2 districts per state with the highest population per household*
- *Find top 2 districts per state with the lowest sex ratios*

Such analyses would help in vivid understanding and timely monitoring of different determinants on well-being and health of population particularly Child and Reproductive Health. Based on the analyses, one can also compare India's position in Global HDI and can suggest ways that can improve it.

I. Data Ingestion from the RDS to HDFS using Sqoop

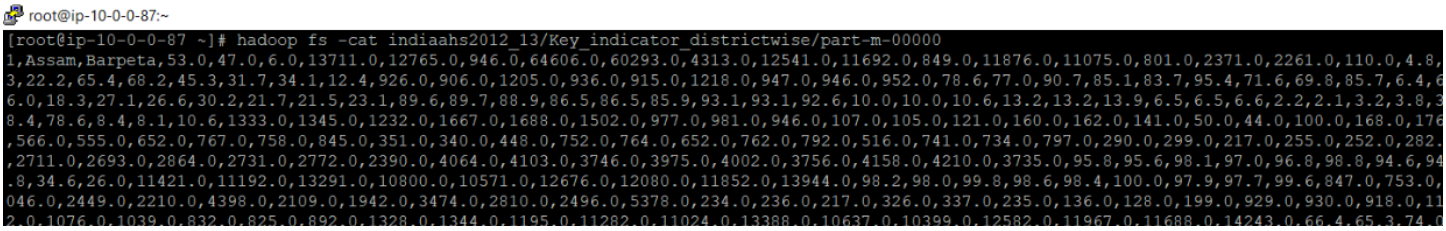
1. Sqoop Import command

sqoop import --connect jdbc:mysql://upgradawsrds1.cyaielc9bmnf.us-east-1.rds.amazonaws.com:3306/indiaahs2012_13 --username upgraduser --password upgraduser --table Key_indicator_districtwise --num-mappers 10 --warehouse-dir indiaahs2012_13



2. Command to see the list of imported data

hadoop fs -cat indiaahs2012_13/Key_indicator_districtwise/part-m-00000



II. External table creation in Hive and loading the ingested data into it. Data ingestion verification.

1. Command to create the external table

```
create external table Key_Indicator_ext_Full (
  > State_Name string,
  > State_District_Name string,
  > YY_Under_Five_Mortality_Rate_U5MR_Total_Person int,
  > LL_Total_Fertility_Rate_Total int,
  > AA_Population_Total int,
  > AA_Households_Total int,
  > CC_Sex_Ratio_All_Ages_Total int)
  > row format delimited
  > fields terminated by ','
  > location '/ key_indicator ';
```

[An external table Key_Indicator_ext_Full is created with selected columns inorder to render the required data]

2. Command to load the ingested data into the external table

```
Load data inpath '/user/root/indiaahs2012_13/Key_indicator_districtwise' into table Key_Indicator_ext_Full;
```

[The Ingested data is loaded into external table created above]

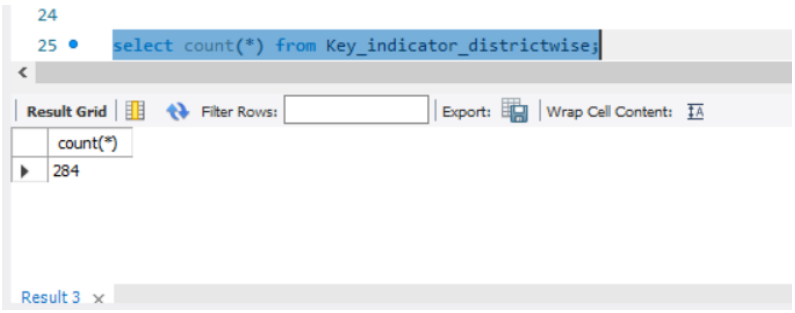
3. Queries to verify that the ingestion is correctly accomplished

a. Query to count the total number of rows along with the screenshots of the data fetched by the query on MySQL Workbench and Hue

Query:

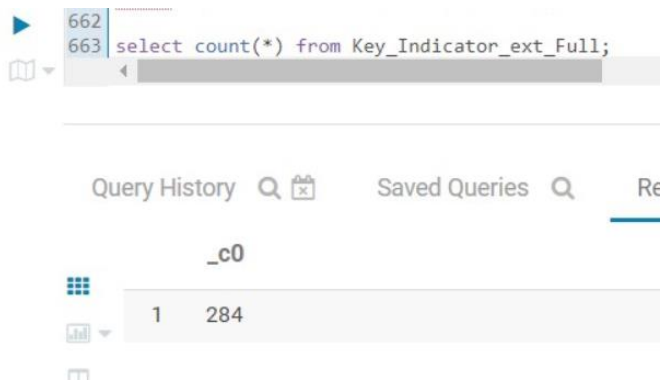
```
Select count(*) from Key_indicator_districtwise;
```

MySQL Workbench:



[Total row count is 284]

Hue:



[Query run in hue and getting the row count as 284]

b. Query to select the top 10 rows and first 8 columns along with the screenshots of the data fetched by the query on MySQL Workbench and Hue

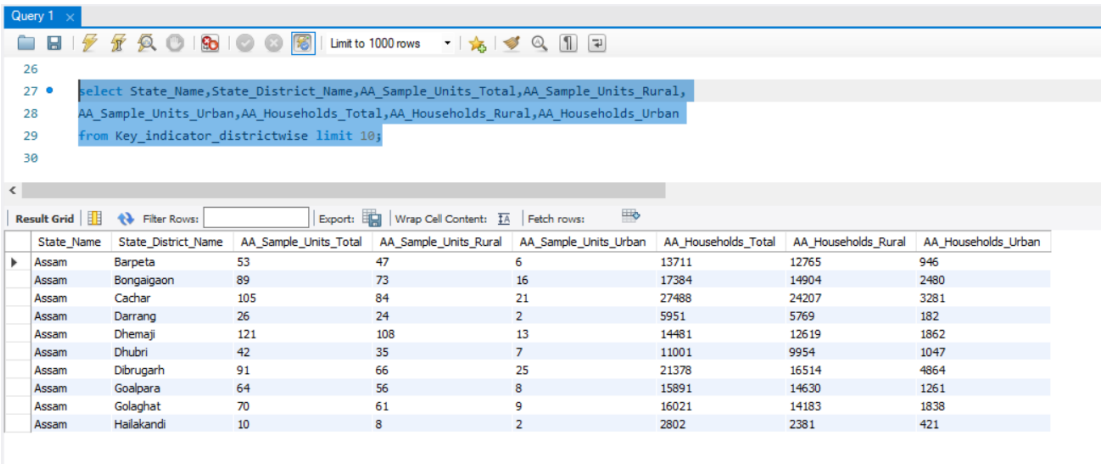
Query:

select State_Name,State_District_Name,AA_Sample_Units_Total,AA_Sample_Units_Rural,

AA_Sample_Units_Urban,AA_Households_Total,AA_Households_Rural,AA_Households_Urban

from Key_indicator_districtwise limit 10;

MySQL Workbench:



State_Name	State_District_Name	AA_Sample_Units_Total	AA_Sample_Units_Rural	AA_Sample_Units_Urban	AA_Households_Total	AA_Households_Rural	AA_Households_Urban
Assam	Barpeta	53	47	6	13711	12765	946
Assam	Bongaigaon	89	73	16	17384	14904	2480
Assam	Cachar	105	84	21	27488	24207	3281
Assam	Darrang	26	24	2	5951	5769	182
Assam	Dhemaji	121	108	13	14481	12619	1862
Assam	Dhubri	42	35	7	11001	9954	1047
Assam	Dibrugarh	91	66	25	21378	16514	4864
Assam	Goalpara	64	56	8	15891	14630	1261
Assam	Golaghat	70	61	9	16021	14183	1838
Assam	Hailakandi	10	8	2	2802	2381	421

Hue:

SELECT State_Name,State_District_Name,AA_Sample_Units_Total,AA_Sample_Units_Rural,

AA_Sample_Units_Urban,AA_Households_Total,AA_Households_Rural,AA_Households_Urban

FROM Key_Indicator_ext_Full LIMIT 10;

state_name	state_district_name	aa_sample_units_total	aa_sample_units_rural	aa_sample_units_urban	aa_households_total	aa_households_rural	aa_households_urban
Assam	Barpeta	53	47	6	13711	12765	946
Assam	Bongaigaon	89	73	16	17384	14904	2480
Assam	Cachar	105	84	21	27488	24207	3281
Assam	Darrang	26	24	2	5951	5769	182
Assam	Dhemaji	121	108	13	14481	12619	1862
Assam	Dhubri	42	35	7	11001	9954	1047
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Assam	Golaghat	70	61	9	16021	14183	1838
Assam	Hailakandi	10	8	2	2802	2381	421

[Verified the outputs from MySQL Workbench and Hue to be same]

III. Subset schema creation in Hive to support the analyses

1. Columns used in the subset schema

>ID

>State_Name

> State_District_Name

> YY_Under_Five_Mortality_Rate_U5MR_Total_Person

> LL_Total_Fertility_Rate_Total

> AA_Population_Total

> AA_Households_Total

> CC_Sex_Ratio_All_Ages_Total

2. Storage format used

- Default
- ORC

3. Create and insert command for the default format

Create command

```
CREATE EXTERNAL TABLE IF NOT EXISTS Key_Indicator_ext_default(
        ID int,
        State_Name string,
        State_District_Name string,
        YY_Under_Five_Mortality_Rate_U5MR_Total_Person double,
        LL_Total_Fertility_Rate_Total double,
        AA_Households_Total double,
        AA_Population_Total double,
        CC_Sex_Ratio_All_Ages_Total double
       )
        LOCATION '/user/root/indiaahs2012_13/Key_indicator_districtwise';
```

Insert command

```
 INSERT INTO Key_indicator_districtwise
SELECT ID,State_Name,State_District_Name,
      YY_Under_Five_Mortality_Rate_U5MR_Total_Person,
      LL_Total_Fertility_Rate_Total,
      AA_Households_Total,
      AA_Population_Total,
      CC_Sex_Ratio_All_Ages_Total
FROM Key_Indicator_ext_full
```

4. Create and insert command for the formats such as ORC

Create command

```
 CREATE EXTERNAL TABLE IF NOT EXISTS Key_Indicator_ext_orc(
ID int,
State_Name string,
State_District_Name       string,
YY_Under_Five_Mortality_Rate_U5MR_Total_Person double,
LL_Total_Fertility_Rate_Total double,
AA_Households_Total double,
AA_Population_Total double,
CC_Sex_Ratio_All_Ages_Total double
)
STORED AS ORC
LOCATION '/user/root/indiaahs2012_13/key_indicator_orc'
tblproperties("orc.compress"="SNAPPY")
```

Insert command

```
 INSERT INTO Key_Indicator_ext_orc
SELECT ID,State_Name,State_District_Name,
    YY_Under_Five_Mortality_Rate_U5MR_Total_Person,
    LL_Total_Fertility_Rate_Total,
    AA_Households_Total,
    AA_Population_Total,
    CC_Sex_Ratio_All_Ages_Total
FROM Key_Indicator_ext_full;
```

5. Create and insert command for the Hive-HBase integrated table

Create command

```
 create table Key_Indicator_ext_hive(
'ID' int,
'State_Name' string,
'State_District_Name' string,
'Mortality_Rate' double,
'Fertility_Rate' double,
'Households' double,
'Population' double,
'Sex_Ratio' double
 )
STORED BY 'org.apache.hadoop.hive.hbase.HBaseStorageHandler'
WITH SERDEPROPERTIES ("hbase.columns.mapping" = ":key,district:State_Name,district:State_District_Name,
serveydata:Mortality_Rate,serveydata:Fertility_Rate,serveydata:Households,serveydata:Population,serveydata:Sex_Ratio"
)
TBLPROPERTIES ("hbase.table.name" = "Key_Indicator_ext__hive_hbase");
```

Insert command

```
insert overwrite table Key_Indicator_ext_hive
select Key_Indicator_ext_full.ID, Key_Indicator_ext_full.State_Name, Key_Indicator_ext_full.State_District_Name,
    Key_Indicator_ext_full.YY_Under_Five_Mortality_Rate_U5MR_Total_Person,
        Key_Indicator_ext_full.LL_Total_Fertility_Rate_Total,
        Key_Indicator_ext_full.AA_Households_Total,
        Key_Indicator_ext_full.AA_Population_Total,
        Key_Indicator_ext_full.CC_Sex_Ratio_All_Ages_Total
from Key_Indicator_ext_full;
```

6. Screenshot of runtimes against each query given above for the default format, formats such as ORC format as well as Hive-Hbase integration

For default format:

Screenshot of run time for query 1

Screenshot of run time for query 2

```
select State_Name, count(*) from Key_Indicator_ext_default group by State_Name;
```

```
INFO  : Ended Job = job_1571418346229_0002
INFO  : MapReduce Jobs Launched:
INFO  : Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 3.07 sec   HDFS Read: 25249 HDFS Write: 120 SUCCESS
INFO  : Total MapReduce CPU Time Spent: 3 seconds 70 msec
INFO  : Completed executing command(queryId=hive_20191018171616_edcfef9a-93d3-444d-b65c-cc592b7ceaea); Time taken: 22.198 s
econds
```

Query History | Saved Queries | Results (9)

	state_name	_c1
1	Assam	23
2	Bihar	37
3	Chhattisgarh	16

Screenshot of run time for query 3

```
select * from Key_Indicator_ext_default where State_Name = 'Uttar Pradesh';
```

```
INFO  : MapReduce Jobs Launched:
INFO  : Stage-Stage-1: Map: 1   Cumulative CPU: 1.84 sec   HDFS Read: 21663 HDFS Write: 4263 SUCCESS
INFO  : Total MapReduce CPU Time Spent: 1 seconds 840 msec
INFO  : Completed executing command(queryId=hive_20191018171818_02999246-f57f-42e7-8bda-02661fa294fa) Time taken: 13.294 s
econds
INFO  : OK
```

Query History | Saved Queries | Results (70)

	key_indicator_ext_default.id	key_indicator_ext_default.state_name	key_indicator_ext_default.state_district_na
1	202	Uttar Pradesh	Agra
2	203	Uttar Pradesh	Aligarh
3	204	Uttar Pradesh	Allahabad

For formats such as ORC:

Screenshot of run time for query 1

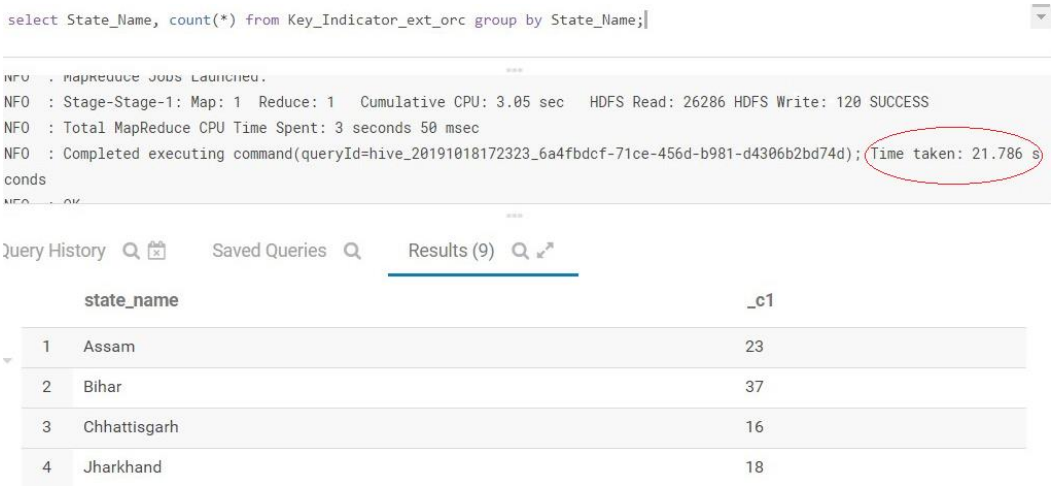
```
select count(*) from Key_Indicator_ext_orc;

NFO  : MapReduce Jobs Launched:
NFO  : Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 2.96 sec   HDFS Read: 25263 HDFS Write: 4 SUCCESS
NFO  : Total MapReduce CPU Time Spent: 2 seconds 960 msec
NFO  : Completed executing command(queryId=hive_20191018172121_d254c959-a50f-4c24-bdca-cdbb46be732e); Time taken: 21.825 s
conds
```

Query History | Saved Queries | Results (1)

	_c0
1	284

Screenshot of run time for query 2



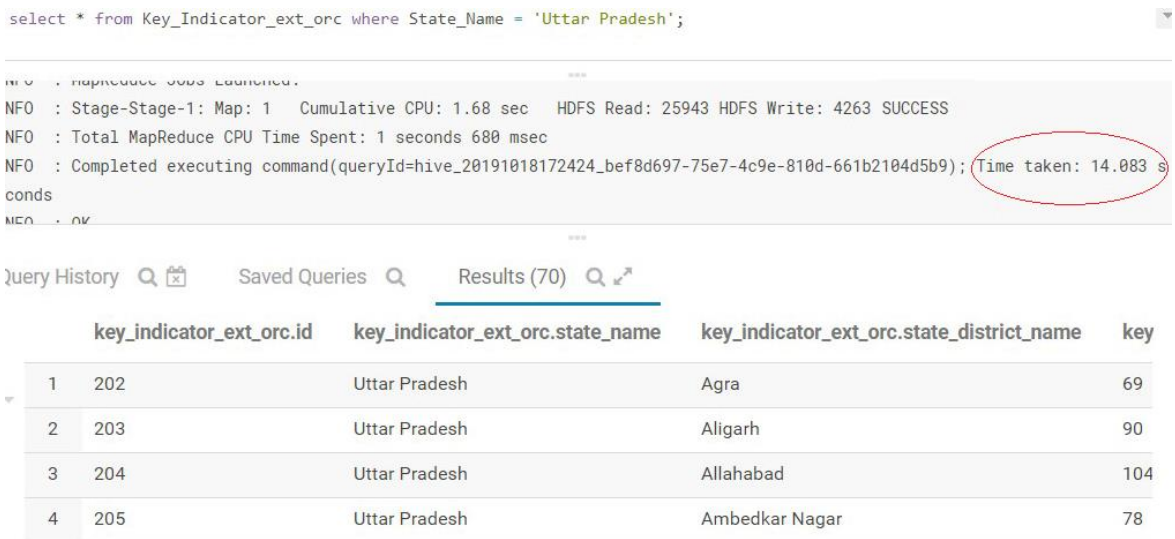
```
select State_Name, count(*) from Key_Indicator_ext_orc group by State_Name;

NFO  : Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 3.05 sec   HDFS Read: 26286 HDFS Write: 120 SUCCESS
NFO  : Total MapReduce CPU Time Spent: 3 seconds 50 msec
NFO  : Completed executing command(queryId=hive_20191018172323_6a4fbdcf-71ce-456d-b981-d4306b2bd74d); Time taken: 21.786 s
conds
```

Query History | Saved Queries | Results (9)

	state_name	_c1
1	Assam	23
2	Bihar	37
3	Chhattisgarh	16
4	Jharkhand	18

Screenshot of run time for query 3



```
select * from Key_Indicator_ext_orc where State_Name = 'Uttar Pradesh';

NFO  : Stage-Stage-1: Map: 1   Cumulative CPU: 1.68 sec   HDFS Read: 25943 HDFS Write: 4263 SUCCESS
NFO  : Total MapReduce CPU Time Spent: 1 seconds 680 msec
NFO  : Completed executing command(queryId=hive_20191018172424_bef8d697-75e7-4c9e-810d-661b2104d5b9); Time taken: 14.083 s
conds
```

Query History | Saved Queries | Results (70)

	key_indicator_ext_orc.id	key_indicator_ext_orc.state_name	key_indicator_ext_orc.state_district_name	key
1	202	Uttar Pradesh	Agra	69
2	203	Uttar Pradesh	Aligarh	90
3	204	Uttar Pradesh	Allahabad	104
4	205	Uttar Pradesh	Ambedkar Nagar	78

For Hive-Hbase Integrated Table:

Screenshot of run time for query 1

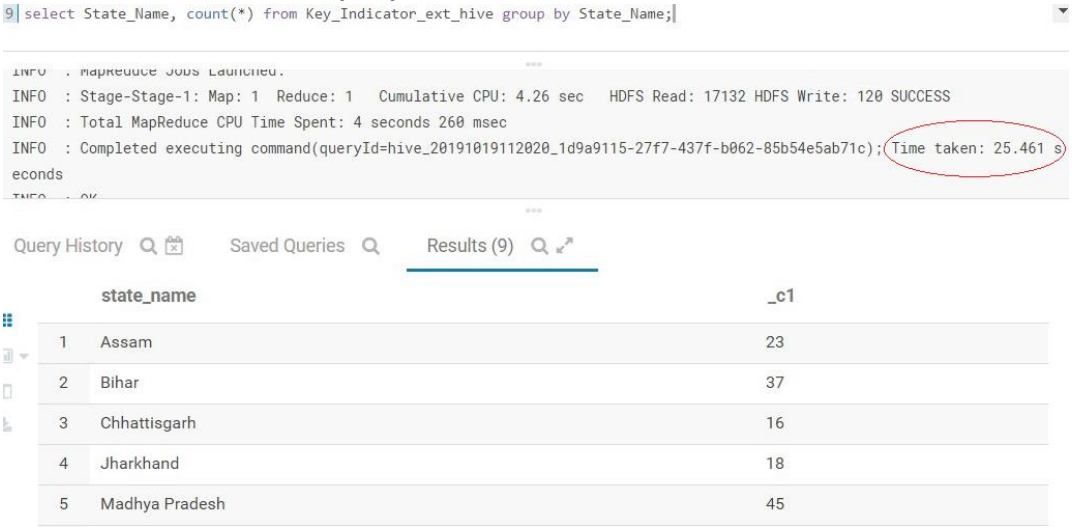
```
select count(*) from Key_Indicator_ext_hive;
```

```
INFO  : Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 3.86 sec   HDFS Read: 16793 HDFS Write: 4 SUCCESS
INFO  : Total MapReduce CPU Time Spent: 3 seconds 860 msec
INFO  : Completed executing command(queryId=hive_20191019111919_ddfe5cff-dc66-481f-a16d-5968df150301); Time taken: 23.824 s
econds
```

Query History | Saved Queries | Results (1)

	_c0
1	284

Screenshot of run time for query 2



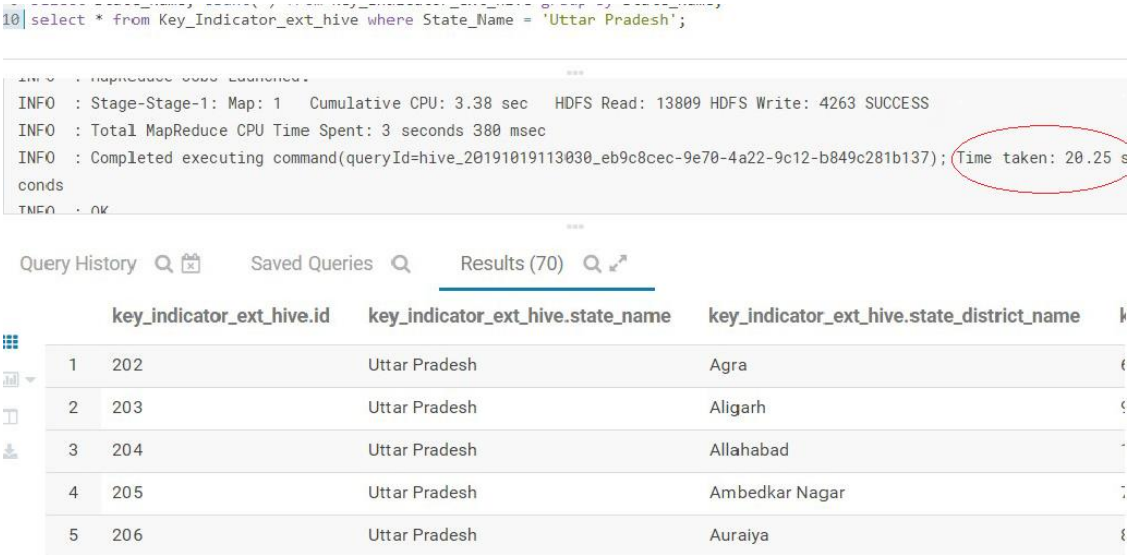
```
select State_Name, count(*) from Key_Indicator_ext_hive group by State_Name;
```

```
INFO  : Stage-Stage-1: Map: 1  Reduce: 1   Cumulative CPU: 4.26 sec   HDFS Read: 17132 HDFS Write: 120 SUCCESS
INFO  : Total MapReduce CPU Time Spent: 4 seconds 260 msec
INFO  : Completed executing command(queryId=hive_20191019112020_1d9a9115-27f7-437f-b062-85b54e5ab71c); Time taken: 25.461 s
econds
```

Query History | Saved Queries | Results (9)

	state_name	_c1
1	Assam	23
2	Bihar	37
3	Chhattisgarh	16
4	Jharkhand	18
5	Madhya Pradesh	45

Screenshot of run time for query 3



```
select * from Key_Indicator_ext_hive where State_Name = 'Uttar Pradesh';
```

```
INFO  : Stage-Stage-1: Map: 1   Cumulative CPU: 3.38 sec   HDFS Read: 13809 HDFS Write: 4263 SUCCESS
INFO  : Total MapReduce CPU Time Spent: 3 seconds 380 msec
INFO  : Completed executing command(queryId=hive_20191019113030_eb9c8cec-9e70-4a22-9c12-b849c281b137); Time taken: 20.25 s
conds
```

Query History | Saved Queries | Results (70)

	key_indicator_ext_hive.id	key_indicator_ext_hive.state_name	key_indicator_ext_hive.state_district_name	k
1	202	Uttar Pradesh	Agra	6
2	203	Uttar Pradesh	Aligarh	9
3	204	Uttar Pradesh	Allahabad	1
4	205	Uttar Pradesh	Ambedkar Nagar	7
5	206	Uttar Pradesh	Auraiya	8

6. Create and insert command for the partition table for analyses 1 & 2.

Create command

```
CREATE EXTERNAL TABLE IF NOT EXISTS Key_Indicator_ext_partition(
ID int,
State_District_Name       string,
YY_Under_Five_Mortality_Rate_U5MR_Total_Person double,
LL_Total_Fertility_Rate_Total double,
AA_Households_Total double,
AA_Population_Total double,
CC_Sex_Ratio_All_Ages_Total double
)
PARTITIONED BY (State_Name string)
STORED AS ORC
LOCATION '/user/root/key_indicator/key_indicator_partition'
tblproperties("orc.compress"="SNAPPY");
```

Insert command

```
INSERT INTO Key_Indicator_ext_partition
PARTITION (State_Name)
SELECT
ID,State_District_Name,YY_Under_Five_Mortality_Rate_U5MR_Total_Person,LL_Total_Fertility_Rate_Total,AA_Households_Total,AA_Population_Total,CC_Sex_Ratio_All_Ages_Total,State_Name
FROM Key_Indicator_ext_orc;
```

IV. Analysis

1. The child mortality rate of Uttar Pradesh

Query

```
SELECT State_Name,
AVG(YY_Under_Five_Mortality_Rate_U5MR_Total_Person) AS Child_Mortality_Rate_UP
FROM Key_Indicator_ext_partition
WHERE State_Name='Uttar Pradesh'
GROUP BY State_Name;
```

Screenshot

2. The fertility rate of Bihar

Query

```
SELECT State_Name,
AVG(LL_Total_Fertility_Rate_Total) AS Fertility_Rate_Bihar
from Key_Indicator_ext_partition
WHERE TRIM(State_Name) = 'Bihar'
GROUP BY State_Name;
```

Screenshot

3. State wise child mortality rate and state wise fertility rate and does high fertility correlate with high child mortality?

- *State wise Child Mortality Rate:*

Query

```
SELECT State_Name ,
AVG(YY_Under_Five_Mortality_Rate_U5MR_Total_Person)  AS Child_Mortality_Rate
from Key_Indicator_ext_partition
GROUP BY State_Name;
```

Screenshot

	state_name	child_mortality_rate
1	Assam	71.43478260869566
2	Bihar	69.62162162162163
3	Chhattisgarh	62.5
4	Jharkhand	53.44444444444444
5	Madhya Pradesh	83.37777777777778
6	Odisha	75.8
7	Rajasthan	75.0625
8	Uttar Pradesh	90.22857142857143
9	Uttarakhand	41.84615384615385

[State wise child mortality and fertility rate is retrieved using the respective queries and there by correlation is calculated]

- *State wise Fertility Rate:*

Query

```
SELECT
State_Name ,
AVG(LL_Total_Fertility_Rate_Total) AS Fertility_Rate
from Key_Indicator_ext_partition
GROUP BY State_Name;
```

Screenshot

	state_name	fertility_rate
1	Assam	2.4
2	Bihar	3.532432432432432
3	Chhattisgarh	2.70125
4	Jharkhand	2.894444444444445
5	Madhya Pradesh	3.031111111111111
6	Odisha	2.28
7	Rajasthan	3.028125
8	Uttar Pradesh	3.3978571428571427
9	Uttarakhand	2.022307692307692

- *Correlation between High Child Mortality and High Fertility:*

Query

```
SELECT CORR(Child_Mortality_Rate,Fertility_Rate) AS Correlation
FROM
(
SELECT
State_Name ,
AVG(YY_Under_Five_Mortality_Rate_U5MR_Total_Person)  AS Child_Mortality_Rate,
AVG(LL_Total_Fertility_Rate_Total) AS Fertility_Rate
from Key_Indicator_ext_partition
GROUP BY State_Name)a;
```

Screenshot

	correlation
1	0.5580197666452783

4. Find top 2 districts per state with the highest population per household

Query on the table with the chosen format such as orc

```
 SELECT State_Name AS State_Name,
      State_District_Name AS State_District_Name,
      pp_per_hh As Population_Per_Household
FROM (
    SELECT State_Name ,
         State_District_Name ,
         (AA_Population_Total/AA_Households_Total) as pp_per_hh,
         RANK() OVER(PARTITION BY State_Name ORDER BY (AA_Population_Total/AA_Households_Total) DESC) AS RNK
    FROM Key_Indicator_ext_orc) a
WHERE RNK IN(1,2);
```

Screenshot of the result

	state_name	state_district_name	population_per_household
1	Assam	Dhemaji	5.2103445894620535
2	Assam	Marigaon	4.978445126406547
3	Bihar	Gopalganj	5.979195301761839
4	Bihar	Nawada	5.944978455419291
5	Chhattisgarh	Durg	4.716408016844732
6	Chhattisgarh	Rajnandgaon	4.651162790697675
7	Jharkhand	Kodarma	5.868167462952465
8	Jharkhand	Giridih	5.787106964805766
9	Madhya Pradesh	Jhabua	5.5903925014645575
10	Madhya Pradesh	Sehore	5.366774132372464
11	Odisha	Bhadrak	4.765950743055191
12	Odisha	Jajapur	4.494145867839397
13	Rajasthan	Dhaulpur	5.810972222222222
14	Rajasthan	Barmer	5.629192111322455
15	Uttar Pradesh	Sant Ravidas Nagar (Bhadohi)	6.210831290394473
16	Uttar Pradesh	Baghpat	6.11956799591002
17	Uttarakhand	Udham Singh Nagar	5.1164532900989546
18	Uttarakhand	Nainital	4.748913659550349

[*Find top 2 districts in each state with the highest population per household is retrieved*]

5. Find top 2 districts per state with the lowest sex ratios

Query on the table with the chosen format such as orc

```
SELECT State_Name,District_Name,Sex_Ratio
FROM(
SELECT
State_Name ,
State_District_Name AS District_Name,
CC_Sex_Ratio_All_Ages_Total AS Sex_Ratio,
DENSE_RANK() OVER(PARTITION BY State_Name ORDER BY CC_Sex_Ratio_All_Ages_Total) AS RNK
from Key_Indicator_ext_orc)a
WHERE a.RNK IN(1,2);
```

Screenshot of the result

	state_name	district_name	sex_ratio
1	Assam	Kamrup	925
	Assam	North Cachar Hills	941
3	Bihar	Pashchim Champaran	894
4	Bihar	Khagaria	900
5	Chhattisgarh	Koriya	937.3
6	Chhattisgarh	Bilaspur	948.43
7	Jharkhand	Dhanbad	913
8	Jharkhand	Bokaro	917
9	Madhya Pradesh	Morena	833.13
10	Madhya Pradesh	Datia	852.12
11	Odisha	Sonapur	941
12	Odisha	Jharsuguda	944
13	Rajasthan	Karauli	837
14	Rajasthan	Dhaulpur	838
15	Uttar Pradesh	Gautam Buddha Nagar	836.82
16	Uttar Pradesh	Shahjahanpur	853.67
17	Uttarakhand	Haridwar	884.93
18	Uttarakhand	Udham Singh Nagar	914.31

[Top 2 District from each state with lowest sex ratio is successfully retrieved]