DATA EXPLAINABILITY CHALLENGE

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SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCES

NUST-SEECS

2020

TOP FIVE REGIONS RANKING BASED ON THE SUCCESS TOWARDS COVID-19

ANALYSES CONSTRAINTS

> **OUT OF ALL THE PARAMETERS WE ARE CONSIDERING THE BELOW MENTIONED PARAMETERS FOR OUR ANALYSES:**

1. Commulative tests performed
2. Commulative tests positive
3. Discharged
4. Commulative Expired (region/province wise)
5. No. of hospitals
6. Total Admitted
7. Admitted Critical
8. Recovered
9. Quarantine Facilities
10. Foreign Transmission Percentage
11. Local Transmission Percentage

> **WE HAVE USED THE ABOVE PARAMETERS AND WITH THE HELP OF PYTHON AND PANDAS PLOTTING FUNCTIONS, WE HAVE VISUALIZED AND DREW COMPARISONS BETWEEN THE VALUES OF THESE PARAMETERS**

> **WE HAVE PERFORMED DATE-TIME SERIES COMPARISON AS THE GIVEN DATA IS RECORDED ON THE BASIS OF DATE**

> **OUR ANALYSES AND INTERPRETATION IS BASED ON THE FOLLOWING COMPARISONS (for every region):**

```
1. Total number of discharged patients with respect to date
2. Total number of recovered patients with respect to date
3. Total number of expired patients with respect to date
4. Total number of positive tested patients with respect to date
5. Total number of tests performed with respect to date
6. Foriegn transmission trends with date
7. Local transmission trends with date
8. Total number of hospitals with respect to date
9. Qurantine Facilities with respect to date
10. Total expired and total recovered patients
11. Total positive tested as well as expired patients
12. Total postive tested as well as recovered patients
13. Positive tested out of all test cases with respect to date
14. Critical patients out of all admitted patients with respect to date

Note: There is a graph for every comparison stated above
```

SOURCE CODE

```
# importing Python libraries

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
```

DATA PREPROCESSING

```
# load dataset
df = pd.read_excel('DEC_Dataset.xlsx')
df.columns # dataset columns
```

```
Index(['Date', 'Region', 'Area (km square)', 'Population (Consensus 2017)',
       'COVID-19 Lockdown (1= no lockdown        2= school closure          3 = Country wide lockdown)',
       'Cumulative Cases', 'Cumulative  tests performed',
       'Cumulative  Test positive', 'Discharged',
       'Cumulative Expired (region/province wise)', 'Home Quarantine',
       'Still admitted', 'No of hospitals ', 'Beds for COVID',
       'Total Admitted', 'Admitted Stable', 'Admitted Critical',
       'Admitted Venilator', 'Home Quarantine.1', 'Recovered',
       'Quarantine Facilities', 'Cumulative Quarantined',
       'Foreign Transmission Percentage ', 'Local Transmission Percentage '],
      dtype='object')
```

```
df.head(3) # showing dataset top 3 values (we have locally sorted the data w.r.t Area before loading)
```

	Date	Region	Area (km square)	Population (Consensus 2017)	COVID-19 Lockdown (1= no lockdown 2= school closure 3 = Country wide lockdown)	Cumulative Cases	Cumulative tests performed	Cumulative Test positive	Discharged	Cumulative Expired (region/province wise)	Home Quarantine	Still admitted	No of hospitals	Beds for COVID	Total Admitted	Admitt Stab
0	2020-03-11 00:00:00	ICT	906	2001579	1	48	80	2	0	0	NaN	2	NaN	NaN	NaN	Na
1	2020-03-12 00:00:00	ICT	906	2001579	1	52	85	2	0	0	NaN	2	NaN	NaN	NaN	Na
2	2020-03-13 00:00:00	ICT	906	2001579	1	57	92	2	0	0	NaN	2	NaN	NaN	NaN	Na

```
print('Total dataset rows: ' ,len(df))
```

```
Total dataset rows:  334
```

```
#calculating mean values of several parameters

avg_discharged = max(df['Discharged'])/len(df)
avg_recovered = max(df['Recovered'].dropna())/len(df)
avg_expired = max(df['Cumulative Expired (region/province wise)'])/len(df)
avg_tests_performed = max(df['Cumulative  tests performed'])/len(df)
avg_positive = max(df['Cumulative  Test positive'])/len(df)
avg_hospitals = max(df['No of hospitals '].dropna())/len(df)
avg_facilities = max(df['Quarantine Facilities'].dropna())/len(df)
avg_for_trans = max(df['Foreign Transmission Percentage '].dropna())/len(df)
avg_loc_trans = max(df['Local Transmission Percentage '].dropna())/len(df)

print('average discharged = ', avg_discharged)
print('average recovered = ', avg_recovered)
print('average expired = ', avg_expired)
```

```
print('average tests performed = ', avg_tests_performed)
print('average positive tested = ', avg_positive)
print('average No. of hospitals = ', avg_hospitals)
print('average facilities in Quarantine = ', avg_facilities)
print('average foreign transmissions = ', avg_for_trans)
print('average local transmissions = ', avg_loc_trans)
```

```
average discharged =  7.7155688622754495
average recovered =  3.37125748502994
average expired =  0.27844311377245506
average tests performed =  214.74850299401197
average positive tested =  16.101796407185628
average No. of hospitals =  0.5988023952095808
average facilities in Quarantine =  0.8353293413173652
average foreign transmissions =  0.002485029940119761
average local transmissions =  0.002754491017964072
```

```
# view region-wise data values' count via group_by regions
df.groupby(['Region']).count().sort_values('Area (km square)')
```

Region	Date	Area (km square)	Population (Consensus 2017)	COVID-19 Lockdown (1= no lockdown 2= school closure 3 = Country wide lockdown)	Cumulative Cases	Cumulative tests performed	Cumulative Test positive	Discharged	Cumulative Expired (region/province wise)	Home Quarantine	Still admitted	No of hospitals	Beds for COVID	Total Admitted	Admitted Stable
KPTD	12	12	12	12	12	12	12	12	12	0	12	0	0	0	0
AJK	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
Balochistan	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
GB	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
ICT	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
KP	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
Punjab	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22
Sindh	46	46	46	46	46	46	46	46	46	28	46	22	22	22	22

```
# transform dates into same format within dataset
df['Date'] = pd.to_datetime(df['Date'])
```

```
# splitting data into dataframes on the basis of regions and sort them on the basis of dates
# there are total 8 regions i.e. ICT, AJK, KPTD, GB, KP, Sindh, Punjab, and Balochistan

ict = df[df['Region'] == 'ICT'].sort_values('Date')
ajk = df[df['Region'] == 'AJK'].sort_values('Date')
kptd = df[df['Region'] == 'KPTD'].sort_values('Date')
gb = df[df['Region'] == 'GB'].sort_values('Date')
```

```
kp = df[df['Region'] == 'KP'].sort_values('Date')
sindh = df[df['Region'] == 'Sindh'].sort_values('Date')
punjab = df[df['Region'] == 'Punjab'].sort_values('Date')
balochistan = df[df['Region'] == 'Balochistan'].sort_values('Date')
```

DATA ANALYSES AND VISUALIZATION

> NOTE: ***We can see that KPTD data is almost near to none, so we are not considering KPTD In our analyses for now.***

> ***1. VISUALIZE REGION-WISE DISCHARGED PATIENTS WITH DATE-TIME SERIES***

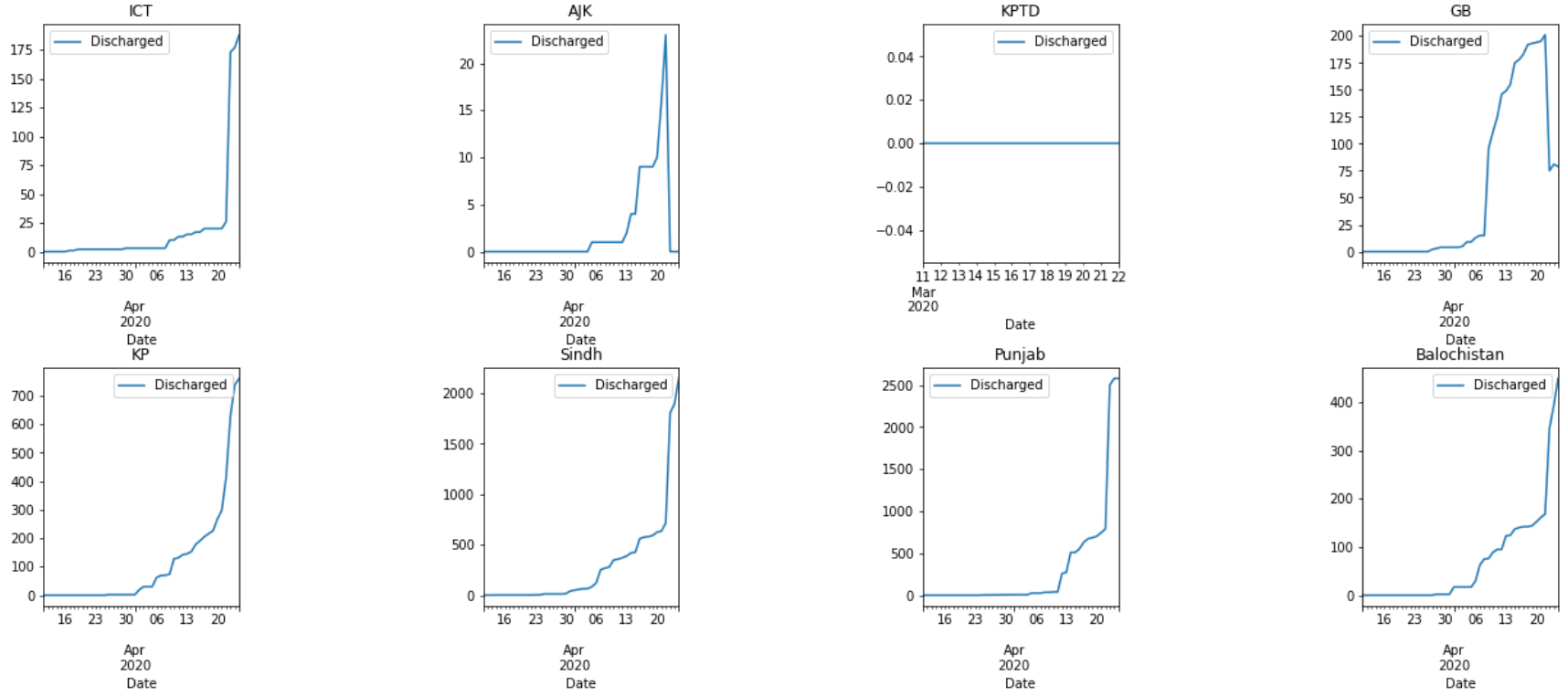
```
#ploting number of discharged patients graph with date for every region

fig, axes = plt.subplots(nrows=2, ncols=4)
fig.tight_layout(pad=2.0)

ict.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='ICT', ax=axes[0,0])
ajk.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='AJK', ax=axes[0,1] )
kptd.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='KPTD', ax=axes[0,2])
gb.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='GB', ax=axes[0,3])

kp.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='KP', ax=axes[1,0])
sindh.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='Sindh', ax=axes[1,1])
punjab.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='Punjab', ax=axes[1,2])
balochistan.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='Balochistan', ax=axes[1,3])
```

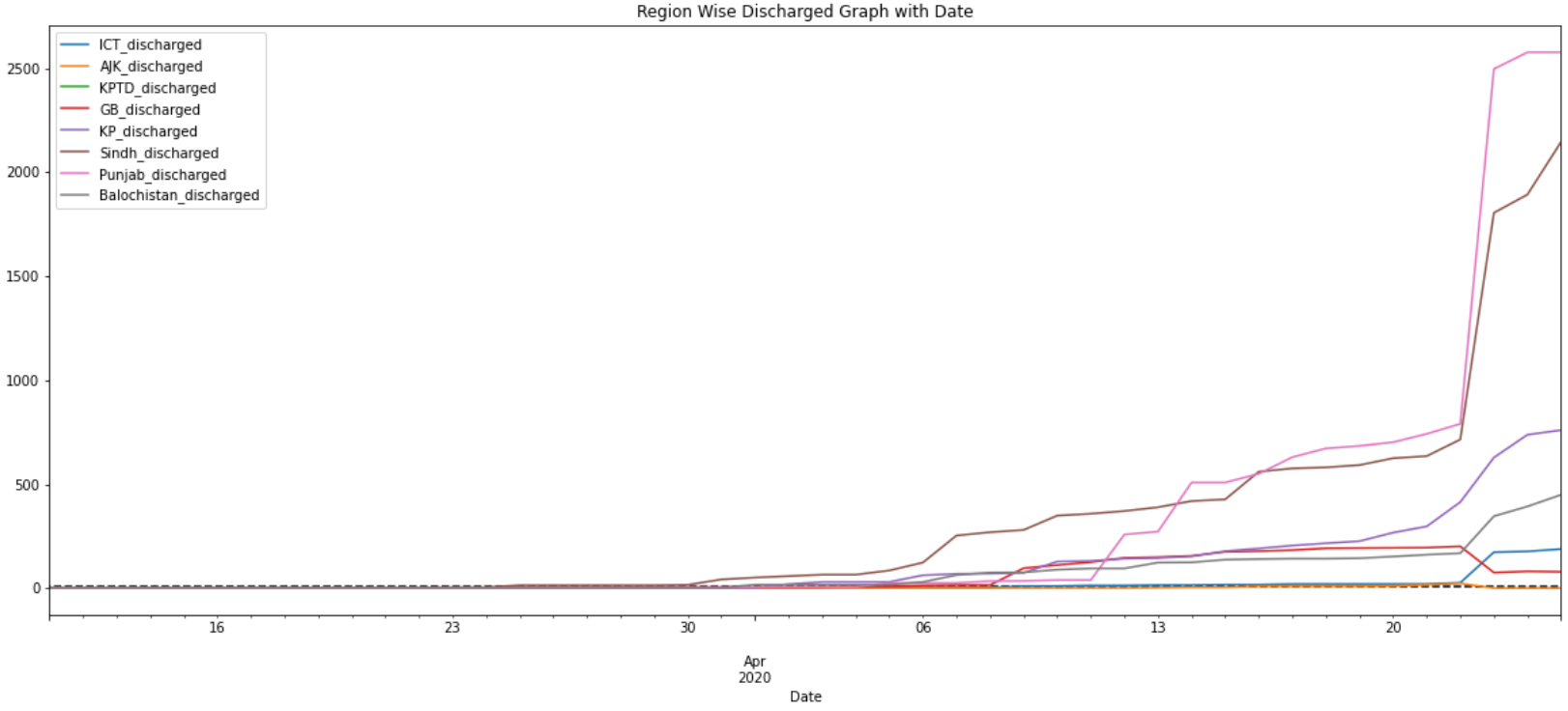
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4e639117b8>
```




```
# ploting Discharged patients rate change with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Discharged', kind='line', figsize=(20,8), title='Region Wise Discharged Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Discharged')
ax2 = kptd.plot(ax=ax1, x ='Date', y='Discharged')
ax3 = gb.plot(ax=ax2, x ='Date', y='Discharged')
ax4 = kp.plot(ax=ax3, x ='Date', y='Discharged')
ax5 = sindh.plot(ax=ax4, x ='Date', y='Discharged')
ax6 = punjab.plot(ax=ax5, x ='Date', y='Discharged')
ax7 = balochistan.plot(ax=ax6, x ='Date', y='Discharged')
ax.legend(["ICT_discharged", "AJK_discharged",'KPTD_discharged','GB_discharged','KP_discharged','Sindh_discharged','Punjab_discharged','Balochistan_discharged']);
ax.hlines(xmin=0, xmax=10000000, y =avg_discharged, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5fa5a518>
```



Dotted line in the graph is showing average value. Ranking of regions with decreasing order of discharge rate is:

1. Punjab
2. Sindh
3. KP
4. Balochistan
5. ICT
6. GB
7. AJK

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

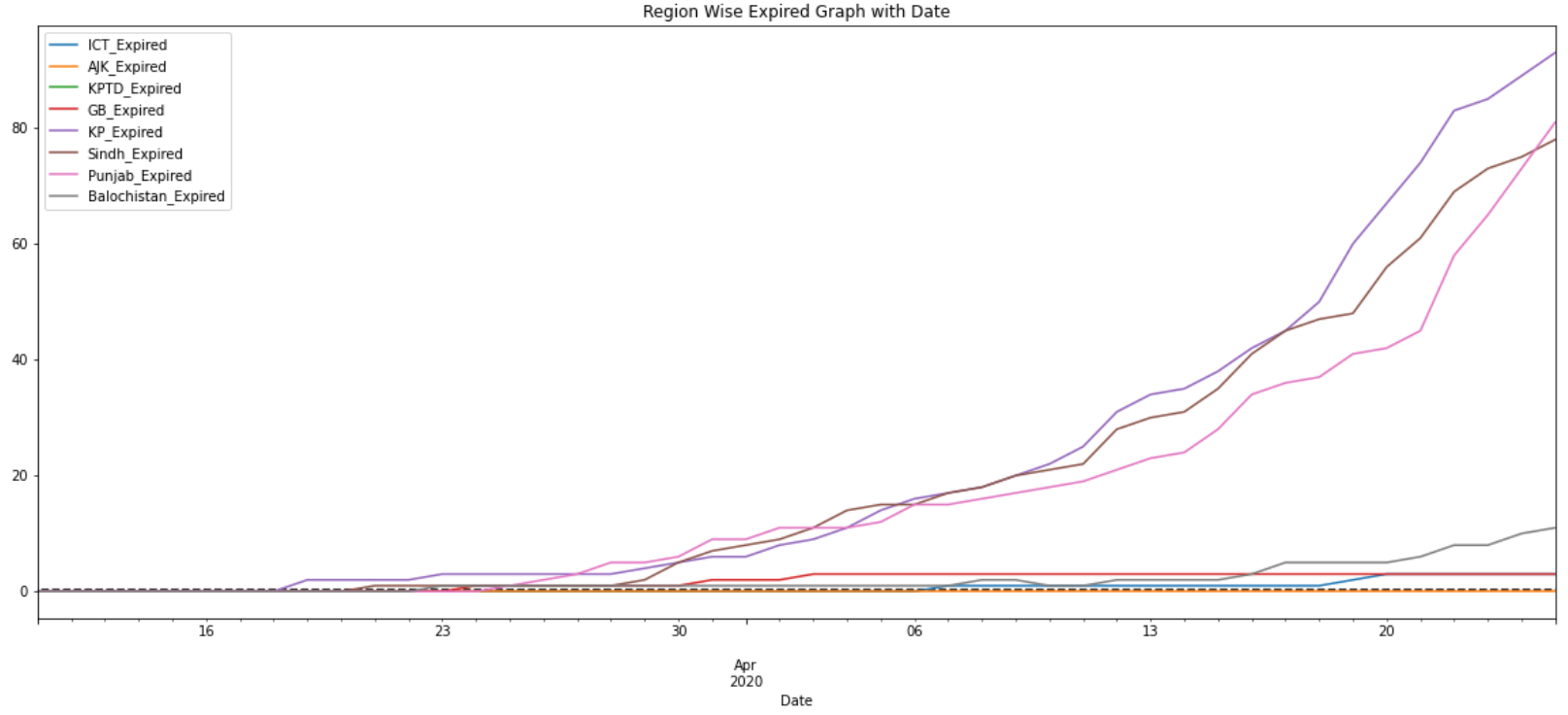
> ***2. VISUALIZE REGION-WISE EXPIRED PATIENTS WITH DATE-TIME SERIES***

```
# ploting Expired patients rate with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Cumulative Expired (region/province wise)', kind='line', figsize=(20,8), title='Region Wise Expired Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Cumulative Expired (region/province wise)')
```

```
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Cumulative Expired (region/province wise)')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Cumulative Expired (region/province wise)')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Cumulative Expired (region/province wise)')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Cumulative Expired (region/province wise)')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Cumulative Expired (region/province wise)')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Cumulative Expired (region/province wise)')
ax.legend(["ICT_Expired", "AJK_Expired",'KPTD_Expired','GB_Expired','KP_Expired','Sindh_Expired','Punjab_Expired','Balochistan_Expired']);
ax.hlines(xmin=0, xmax=10000000, y =avg_expired, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e63a5a630>
```



Dotted line in the graph is showing average value. Ranking of regions with decreasing order of expired rate are:

1. AJK
2. GB
3. ICT
4. Balochistan
5. Punjab
6. Sindh
7. KP

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

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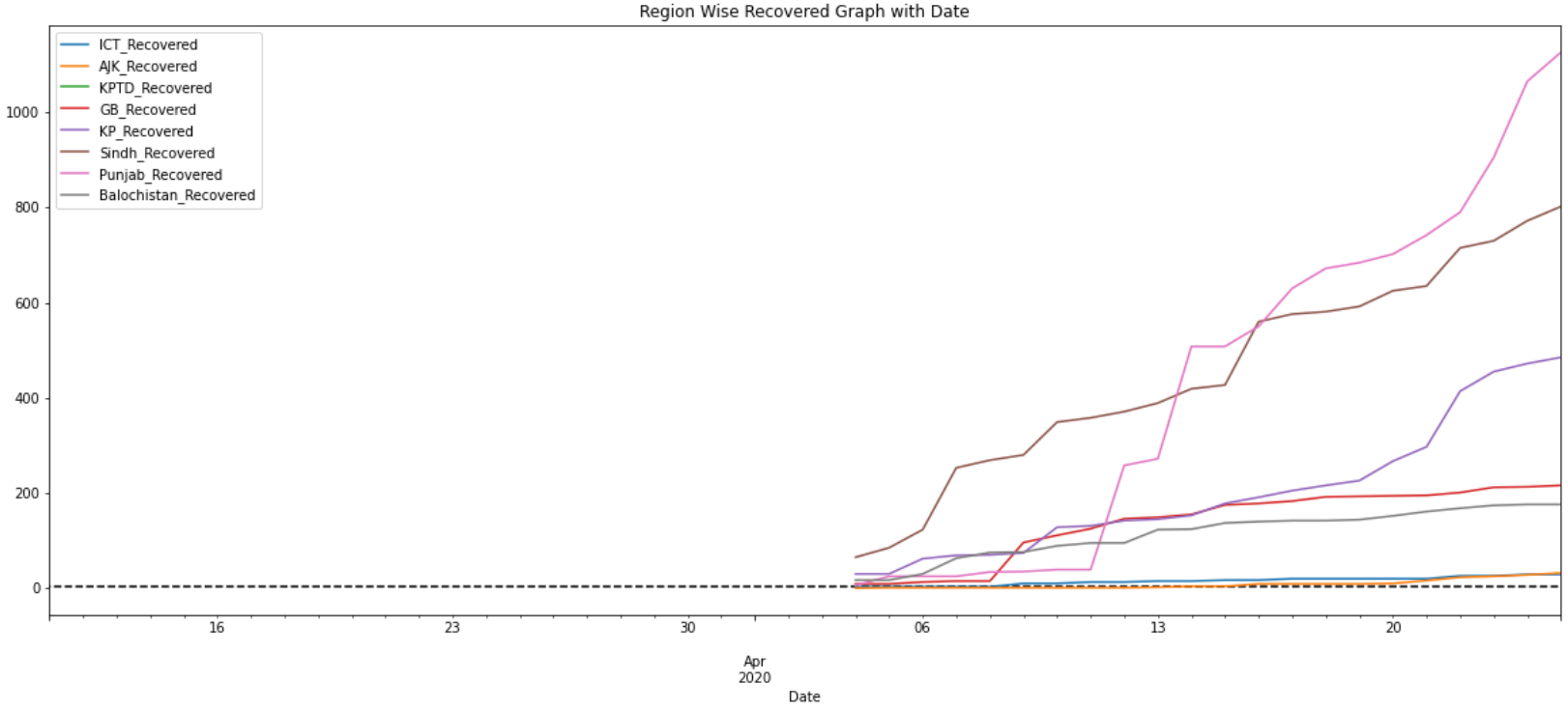
3. VISUALIZE REGION-WISE RECOVERED PATIENTS WITH DATE-TIME SERIES

```
# ploting Recovered patients rate change with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Recovered', kind='line', figsize=(20,8), title='Region Wise Recovered Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Recovered')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Recovered')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Recovered')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Recovered')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Recovered')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Recovered')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Recovered')
ax.legend(["ICT_Recovered", "AJK_Recovered",'KPTD_Recovered','GB_Recovered','KP_Recovered','Sindh_Recovered','Punjab_Recovered','Balochistan_Recovered']);
ax.hlines(xmin=0, xmax=10000000, y =avg_recovered, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5f3f1cf8>
```



> Here the empty region of Graph is showing the unavailability of data in the respective dates

Dotted line in the graph is showing average value. Ranking of regions with decreasing order of recovered rate is:

1. Punjab
2. Sindh
3. KP
4. GB
5. Balochistan
6. AJK
7. ICT

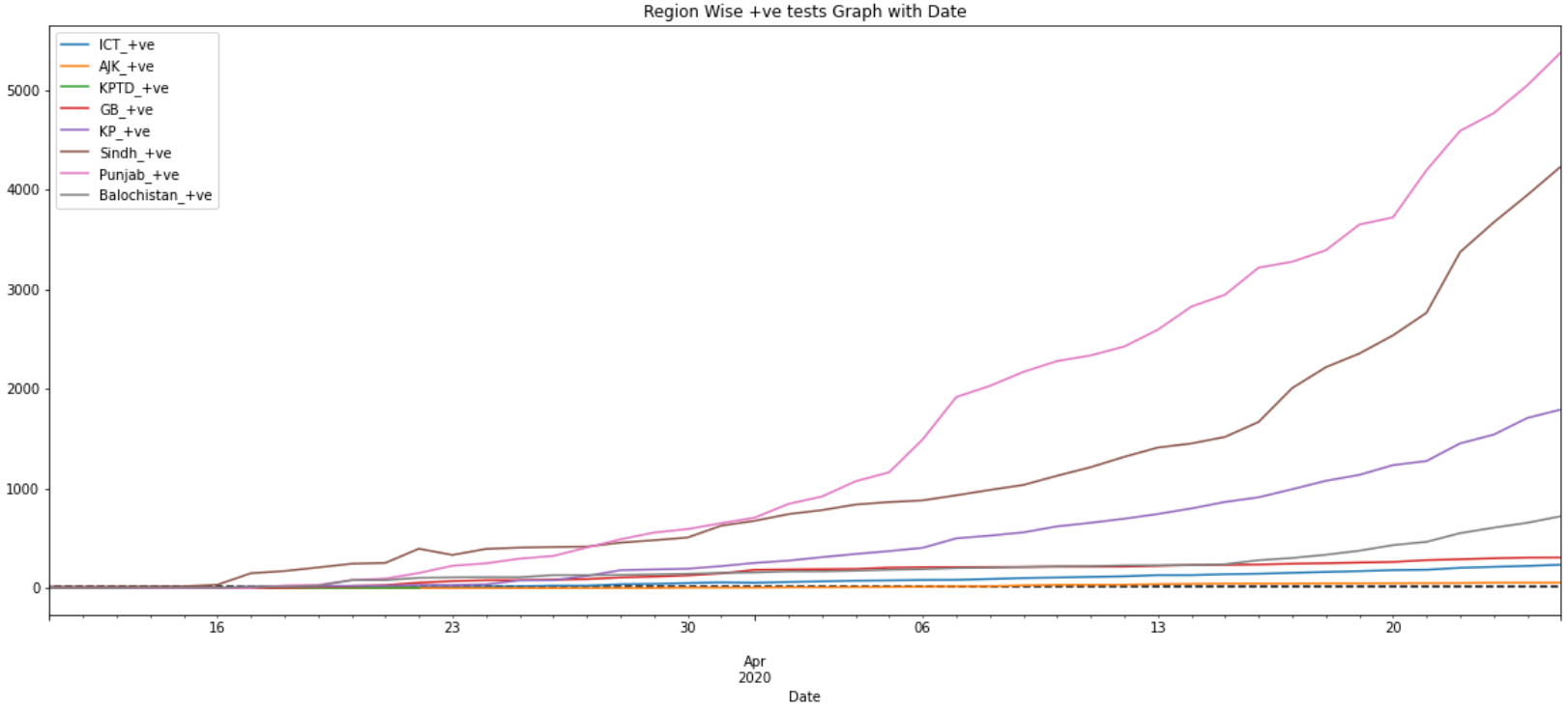
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

> ***4. VISUALIZE REGION-WISE POSITVE TESTED PATIENTS WITH DATE-TIME SERIES***

```
# ploting Positive Tested Patients rate with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Cumulative  Test positive', kind='line', figsize=(20,8), title='Region Wise +ve tests Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Cumulative  Test positive')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Cumulative  Test positive')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Cumulative  Test positive')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Cumulative  Test positive')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Cumulative  Test positive')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Cumulative  Test positive')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Cumulative  Test positive')
ax.legend(["ICT_+ve", "AJK_+ve",'KPTD_+ve','GB_+ve','KP_+ve','Sindh_+ve','Punjab_+ve','Balochistan_+ve']);
ax.hlines(xmin=0, xmax=10000000, y =avg_positive, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5faec3c8>
```



Dotted line in the graph is showing average value. Ranking of regions with the decreasing order of positive tested rate are:

1. AJK
2. ICT
3. GB
4. Balochistan
5. KP
6. Sindh
7. Punjab

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

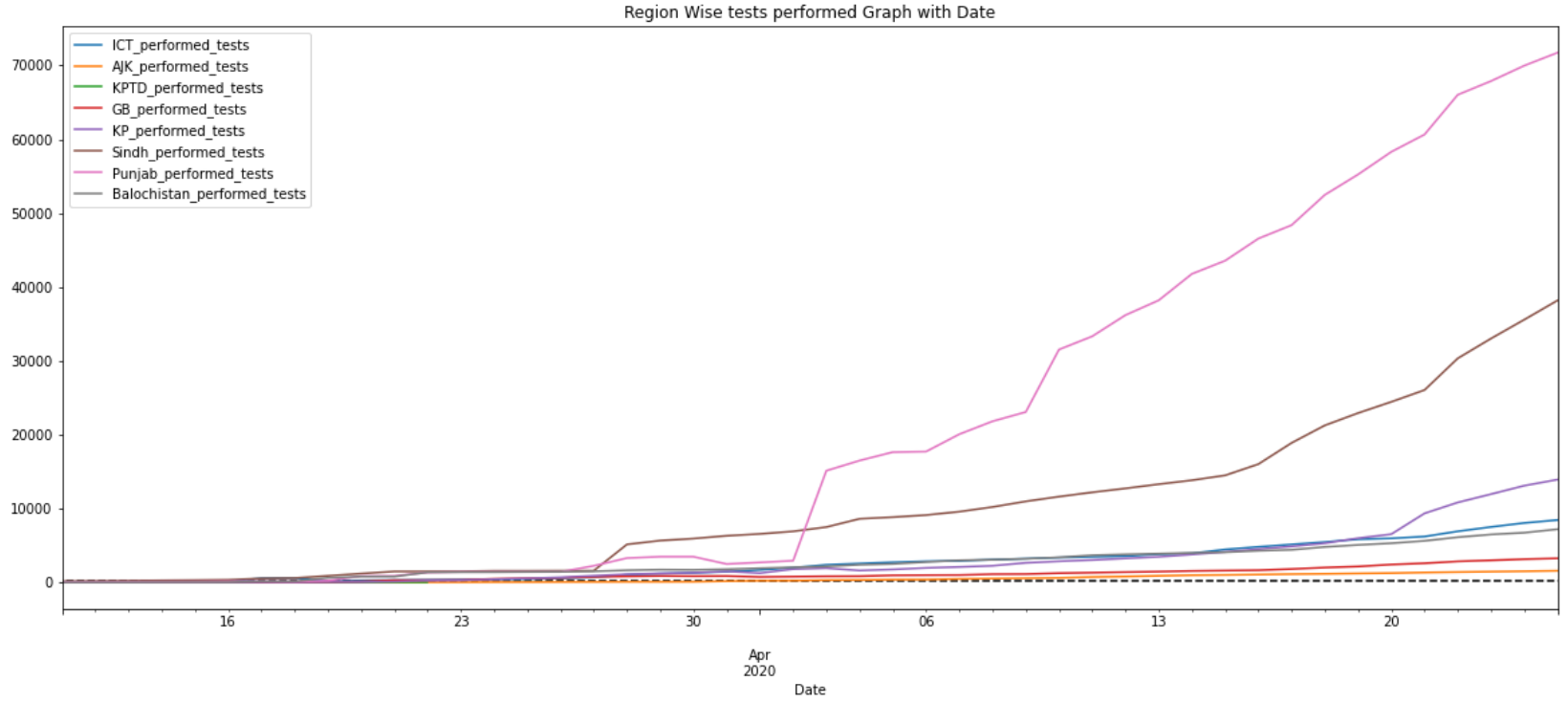
> ***5. VISUALIZE REGION-WISE TESTS PERFORMED WITH DATE-TIME SERIES***

```
# ploting Number of Tests Performed with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Cumulative  tests performed', kind='line', figsize=(20,8), title='Region Wise tests performed Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Cumulative  tests performed')
```

```
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Cumulative  tests performed')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Cumulative  tests performed')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Cumulative  tests performed')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Cumulative  tests performed')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Cumulative  tests performed')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Cumulative  tests performed')
ax.legend(["ICT_performed_tests", "AJK_performed_tests",'KPTD_performed_tests','GB_performed_tests','KP_performed_tests','Sindh_performed_tests','Punjab_performed_tests','Balc
ax.hlines(xmin=0, xmax=10000000, y =avg_tests_performed, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5fb25898>
```



Dotted line in the graph is showing average value. Ranking of regions in the decreasing order of tests performed is:

1. Punjab
2. Sindh
3. KP
4. ICT
5. Balochistan
6. GB
7. AJK

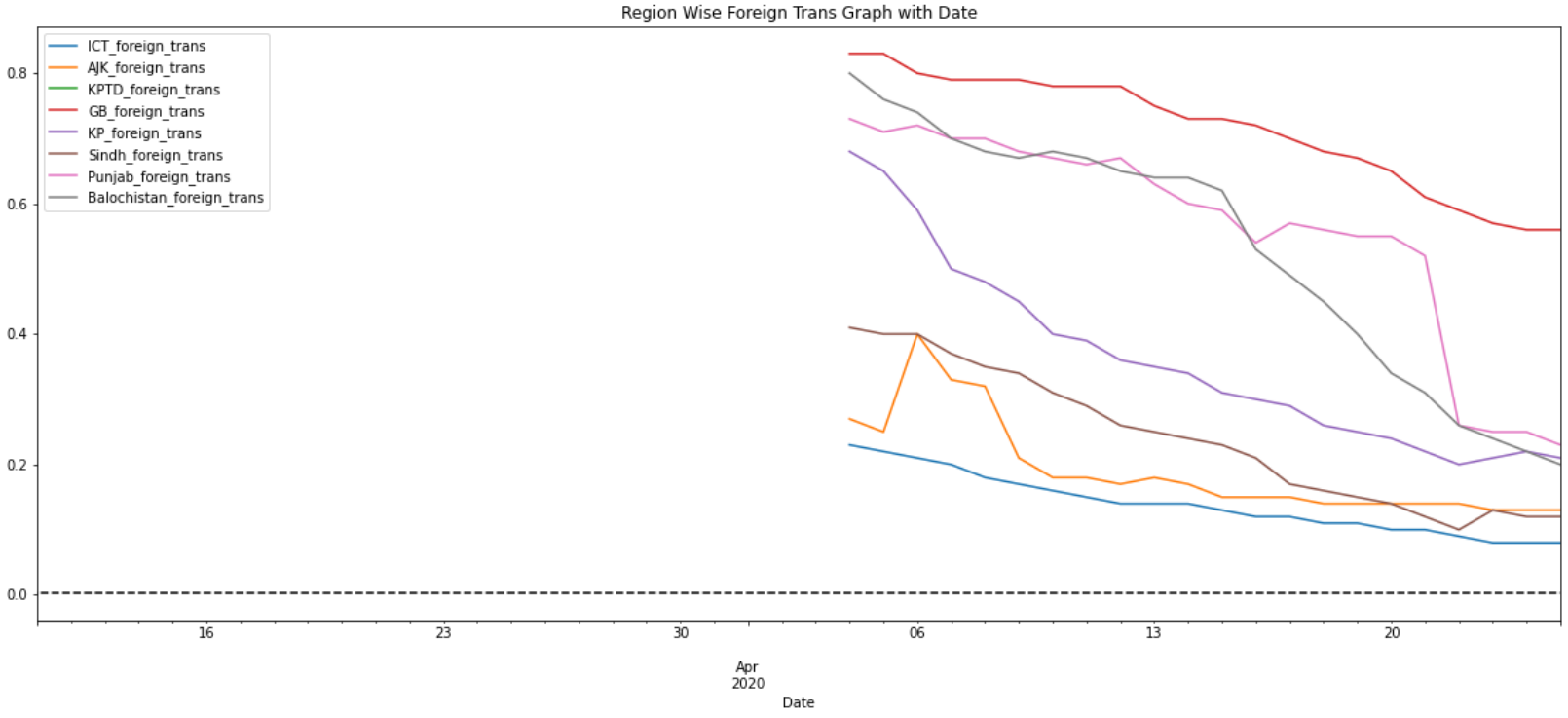
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

6. VISUALIZE REGION-WISE FOREIGN TRANSMISSION PERCENTAGES WITH DATE-TIME SERIES

```
# ploting Foreign Transmission Percentage rates with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Foreign Transmission Percentage ', kind='line', figsize=(20,8), title='Region Wise Foreign Trans Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Foreign Transmission Percentage ')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Foreign Transmission Percentage ')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Foreign Transmission Percentage ')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Foreign Transmission Percentage ')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Foreign Transmission Percentage ')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Foreign Transmission Percentage ')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Foreign Transmission Percentage ')
ax.legend(["ICT_foreign_trans", "AJK_foreign_trans",'KPTD_foreign_trans','GB_foreign_trans','KP_foreign_trans','Sindh_foreign_trans','Punjab_foreign_trans','Balochistan_foreig
ax.hlines(xmin=0, xmax=10000000, y =avg_for_trans, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5f347320>
```



We can see decreasing trend in foriegn transmission of COVID-19 in all the regions. Dotted line in the graph is showing average value. Ranking of regions with better control over foreign transmissions is:

1. ICT
2. Sindh

```
3. AJK
4. KP
5. Balochistan
6. Punjab
7. GB
```

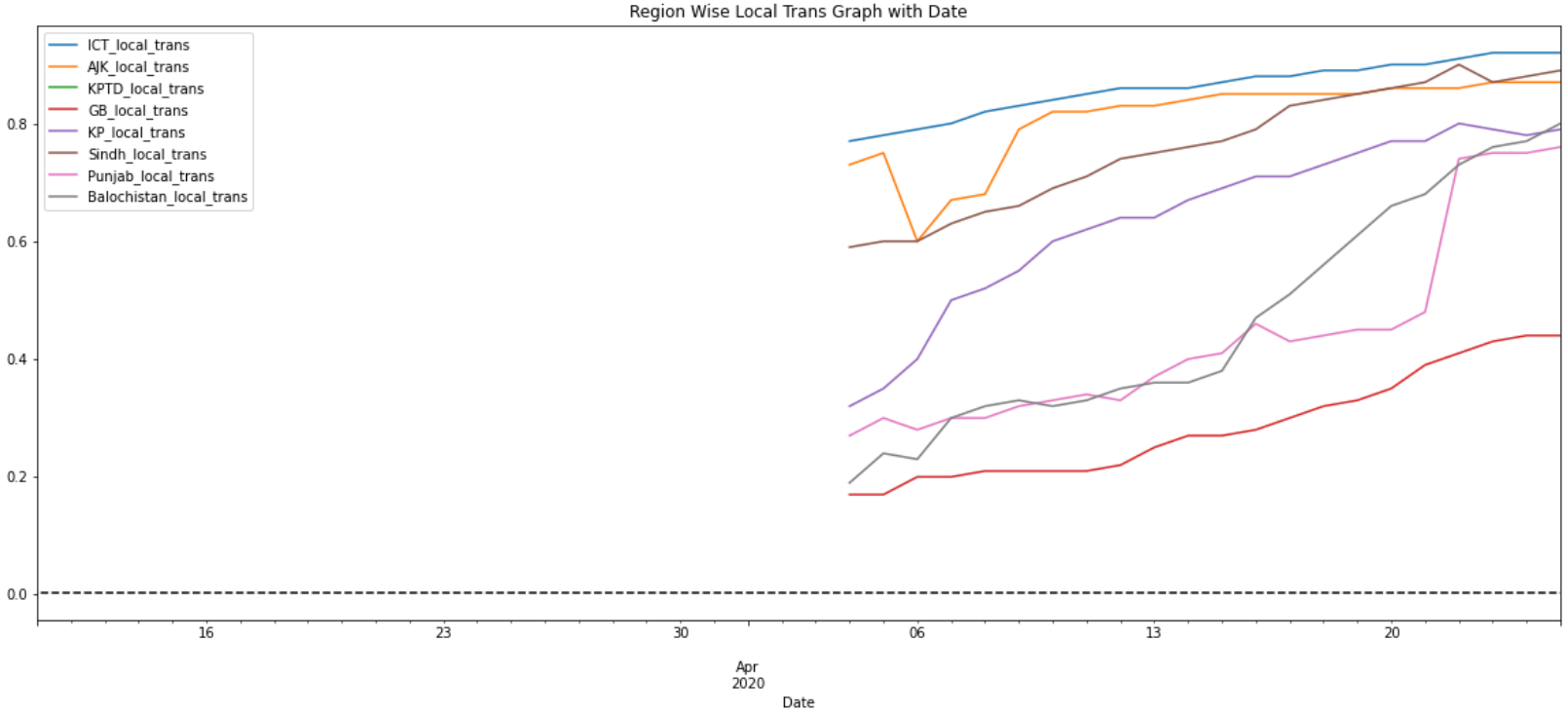
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

> ***7. VISUALIZE REGION-WISE LOCAL TRANSMISSION PERCENTAGES WITH DATE-TIME SERIES***

```
# ploting Local Transmission Percentage's rate with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='Local Transmission Percentage ', kind='line', figsize=(20,8), title='Region Wise Local Trans Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Local Transmission Percentage ')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Local Transmission Percentage ')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Local Transmission Percentage ')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Local Transmission Percentage ')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Local Transmission Percentage ')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Local Transmission Percentage ')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Local Transmission Percentage ')
ax.legend(["ICT_local_trans", "AJK_local_trans",'KPTD_local_trans','GB_local_trans','KP_local_trans','Sindh_local_trans','Punjab_local_trans','Balochistan_local_trans']);
ax.hlines(xmin=0, xmax=10000000, y =avg_loc_trans, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5d5e65f8>
```



We can see an increasing trend in the local transmission of COVID-19 in all the regions. Dotted line in the graph is showing average value.
Ranking of regions with better control over local transmissions is:

1. ICT
2. AJK
3. Sindh
4. KP
5. Balochistan
6. Punjab
7. GB

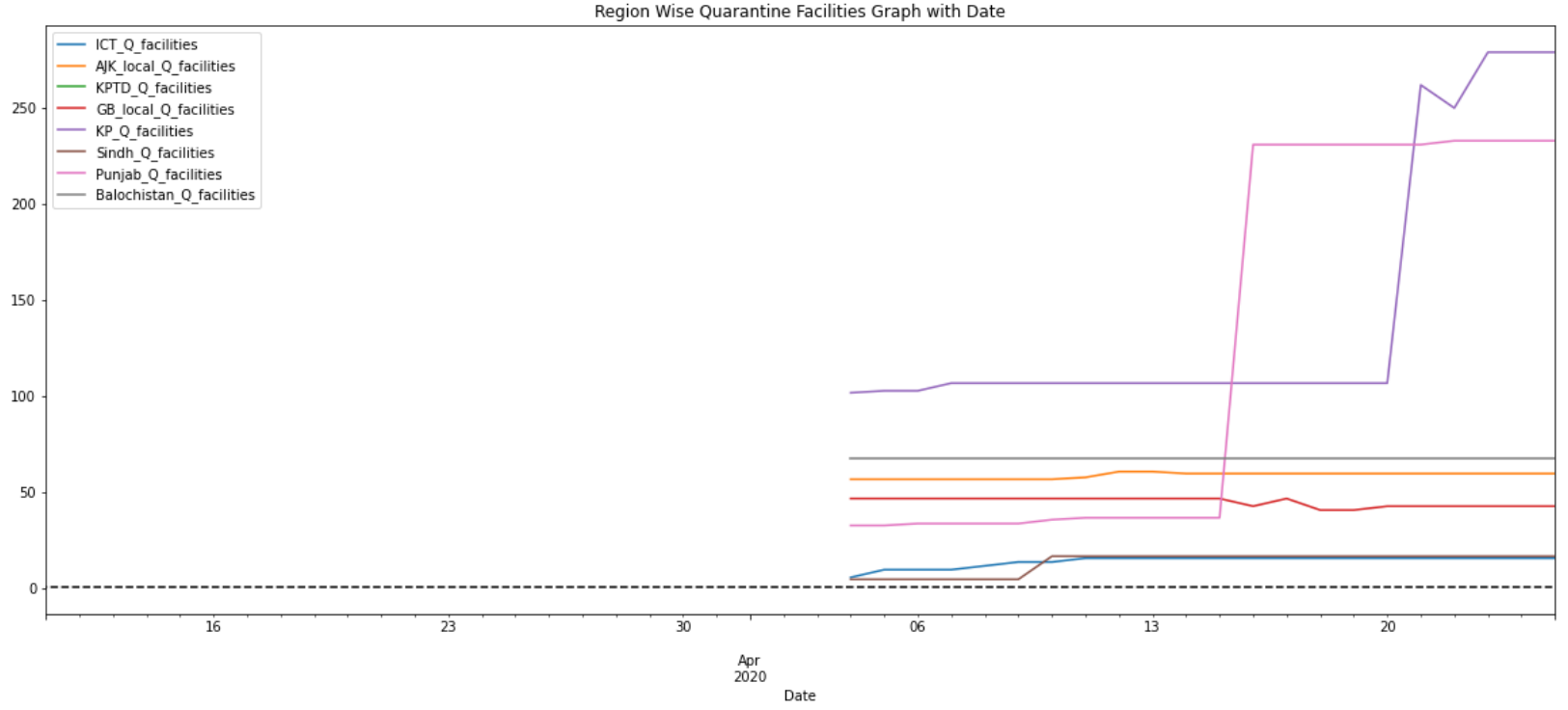
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

> ***8. VISUALIZE REGION-WISE QUARANTINE FACILITIES RATING WITH DATE-TIME SERIES***

```
# ploting Quarantine Facilities Rating with Date for every region on one graph to see the difference
```

```
ax = ict.plot(x ='Date', y='Quarantine Facilities', kind='line', figsize=(20,8), title='Region Wise Quarantine Facilities Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Quarantine Facilities')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Quarantine Facilities')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Quarantine Facilities')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Quarantine Facilities')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Quarantine Facilities')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Quarantine Facilities')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Quarantine Facilities')
ax.legend(["ICT_Q_facilities", "AJK_local_Q_facilities",'KPTD_Q_facilities','GB_local_Q_facilities','KP_Q_facilities','Sindh_Q_facilities','Punjab_Q_facilities','Balochistan_Q
ax.hlines(xmin=0, xmax=10000000, y =avg_facilities, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5d461cc0>
```



Dotted line in the graph is showing average value. Ranking of regions with decreasing order of quarantine facilities is:

1. KP
2. Punjab
3. Balochistan
4. AJK
5. GB
6. Sindh
7. ICT

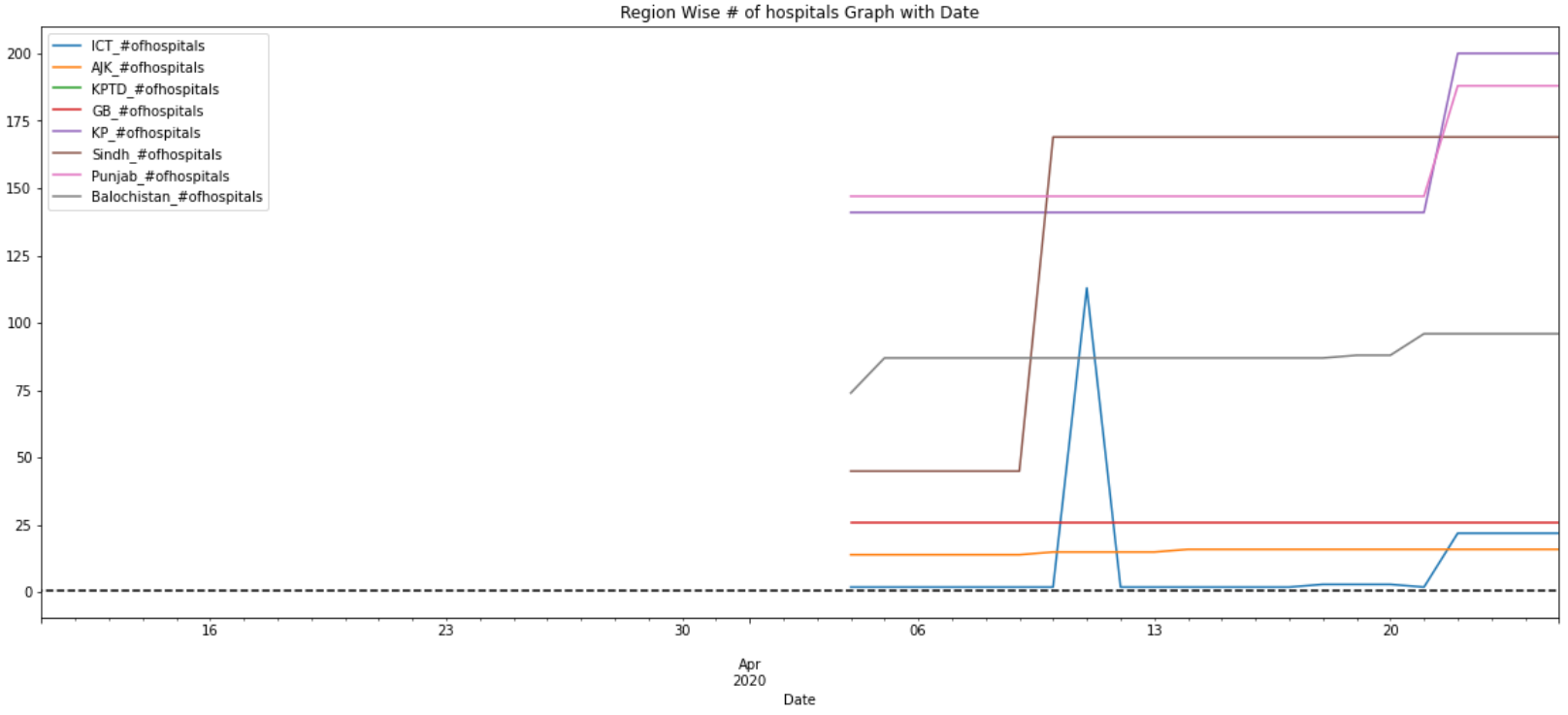
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will

> ***9. VISUALIZE REGION-WISE NUMBER OF HOSPITALS WITH DATE-TIME SERIES***

```
# ploting Number of Hospitals trend with Date for every region on one graph to see the difference

ax = ict.plot(x ='Date', y='No of hospitals ', kind='line', figsize=(20,8), title='Region Wise # of hospitals Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='No of hospitals ')
ax2 = kptd.plot(ax=ax1, x ='Date', y='No of hospitals ')
ax3 = gb.plot(ax=ax2, x ='Date', y='No of hospitals ')
ax4 = kp.plot(ax=ax3, x ='Date', y='No of hospitals ')
ax5 = sindh.plot(ax=ax4, x ='Date', y='No of hospitals ')
ax6 = punjab.plot(ax=ax5, x ='Date', y='No of hospitals ')
ax7 = balochistan.plot(ax=ax6, x ='Date', y='No of hospitals ')
ax.legend(["ICT_#ofhospitals", "AJK_#ofhospitals",'KPTD_#ofhospitals','GB_#ofhospitals','KP_#ofhospitals','Sindh_#ofhospitals','Punjab_#ofhospitals','Balochistan_#ofhospitals'
ax.hlines(xmin=0, xmax=10000000, y =avg_hospitals, linestyles='dashed', color='black')
```

```
<matplotlib.collections.LineCollection at 0x7f4e5d537a20>
```



> Here the empty region of Graph is showing the unavailability of data in the respective dates

Dotted line in the graph is showing average value. Ranking of regions with decreasing order of number of hospitals is:

1. KP
2. Punjab
3. Sindh
4. Balochistan
5. GB
6. ICT
7. AJK

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with 5 regions as required.

```
# Getting the range of values to use in the analyses further
print('Dataset End Values for every region is printed value-1 : ')
print("ICT: ", len(ict))
print("AJK: ", len(ict)+len(ajk))
print("KPTD: ", len(ict)+len(ajk)+len(kptd))
print("GB: ", len(ict)+len(ajk)+len(kptd)+len(gb))
print("KP: ", len(ict)+len(ajk)+len(kptd)+len(gb)+len(kp))
print("Sindh: ", len(ict)+len(ajk)+len(kptd)+len(gb)+len(kp)+len(sindh))
print("Punjab: ", len(ict)+len(ajk)+len(kptd)+len(gb)+len(kp)+len(sindh)+len(punjab))
print("Balochistan: ", len(ict)+len(ajk)+len(kptd)+len(gb)+len(kp)+len(sindh)+len(punjab)+len(balochistan))
```

```
Dataset End Values for every region is printed value-1 :
ICT:  46
AJK:  92
KPTD:  104
GB:  150
KP:  196
Sindh:  242
Punjab:  288
Balochistan:  334
```

```
# region-wise Expired vs Recovered Data

Regions = ['ICT', 'AJK', 'KPTD', 'GB', 'KP', 'Sindh', 'Punjab', 'Balochistan']

exp = [ict['Cumulative Expired (region/province wise)'][45], ajk['Cumulative Expired (region/province wise)'][91], kptd['Cumulative Expired (region/province wise)'][103], gb['

rec = [ict['Recovered'][45], ajk['Recovered'][91], kptd['Recovered'][103], gb['Recovered'][149], kp['Recovered'][195], sindh['Recovered'][241], punjab['Recovered'][287], baloc
```

```
# create DataFrame from above data
exp_rec_df = pd.DataFrame({'expired': exp,
                   'recovered': rec}, index=Regions)
```

```
# showing total number of Expired and Recovered patients for every region
exp_rec_df
```

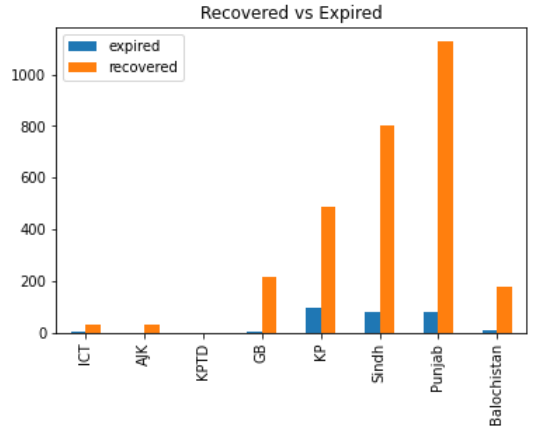
	expired	recovered
ICT	3	29.0
AJK	0	32.0
KPTD	0	NaN
GB	3	216.0
KP	93	485.0
Sindh	78	802.0
Punjab	81	1126.0
Balochistan	11	176.0

> ***10. VISUALIZE REGION-WISE TOTAL EXPIRED AND RECOVRED PATIENTS***

```
# plotting total number of Expired vs Recovered patients for every region

exp_rec_df.plot(kind='bar', title='Recovered vs Expired')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4e63a74b38>
```




```
# region-wise Expired vs total Number of Positive Tested Patients Data

Regions = ['ICT', 'AJK', 'KPTD', 'GB', 'KP', 'Sindh', 'Punjab', 'Balochistan']

exp = [ict['Cumulative Expired (region/province wise)'][45], ajk['Cumulative Expired (region/province wise)'][91], kptd['Cumulative Expired (region/province wise)'][103], gb['

pos = [ict['Cumulative  Test positive'][45],ajk['Cumulative  Test positive'][91], kptd['Cumulative  Test positive'][103], gb['Cumulative  Test positive'][149] , kp['Cumulative
```

```
# create DataFrame from above data
exp_pos_df = pd.DataFrame({'expired': exp,
                   'positive': pos}, index=Regions)
```

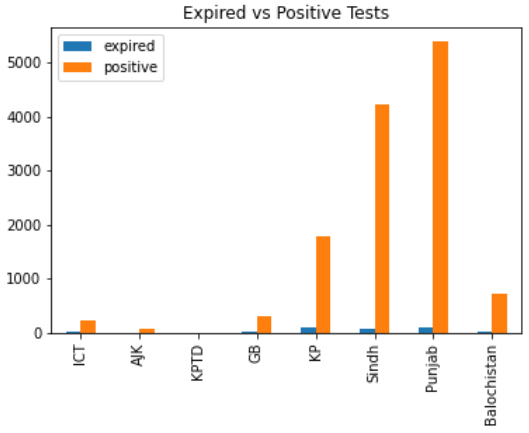
```
# showing total number of Expired and Positive Tested Patients for every region
exp_pos_df
```

	expired	positive
ICT	3	235
AJK	0	55
KPTD	0	0
GB	3	308
KP	93	1793
Sindh	78	4232
Punjab	81	5378
Balochistan	11	722

> ***11. VISUALIZE REGION-WISE TOTAL POSITVE TESTED PATIENTS WHO ARE EXPIRED***

```
# plotting total number of Expired vs Postive Tested patients for every region
exp_pos_df.plot(kind='bar', title='Expired vs Positive Tests')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4e5d1c4eb8>
```




```
# region-wise Total Recovered vs total Number of Postive Tested Patients Data

Regions = ['ICT', 'AJK', 'KPTD', 'GB', 'KP', 'Sindh', 'Punjab', 'Balochistan']

rec = [ict['Recovered'][45], ajk['Recovered'][91], kptd['Recovered'][103], gb['Recovered'][149], kp['Recovered'][195], sindh['Recovered'][241], punjab['Recovered'][287], baloc

pos = [ict['Cumulative  Test positive'][45],ajk['Cumulative  Test positive'][91], kptd['Cumulative  Test positive'][103], gb['Cumulative  Test positive'][149] , kp['Cumulative
```

```
# creat DataFrame from above data
rec_pos_df = pd.DataFrame({'recovered': rec,
```

```
                'positive': pos}, index=Regions)
```

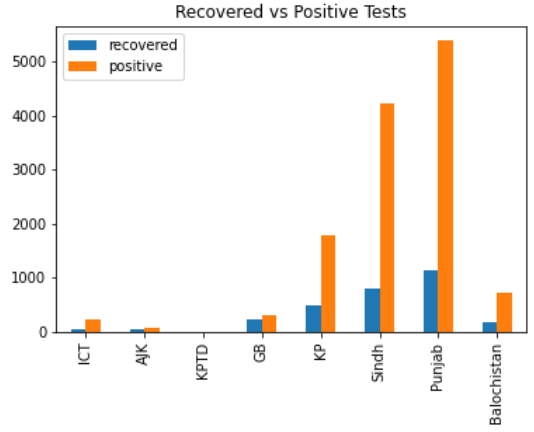
```
# show total number of recovered and positive tested patients for every region
rec_pos_df
```

	recovered	positive
ICT	29.0	235
AJK	32.0	55
KPTD	NaN	0
GB	216.0	308
KP	485.0	1793
Sindh	802.0	4232
Punjab	1126.0	5378
Balochistan	176.0	722

12. VISUALIZE REGION-WISE POSITVE TESTED PATIENTS WHO ARE RECOVERED

```
# plotting total number of recovered and positive tested patients for every region
rec_pos_df.plot(kind='bar', title='Recovered vs Positive Tests')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4e5d635128>
```

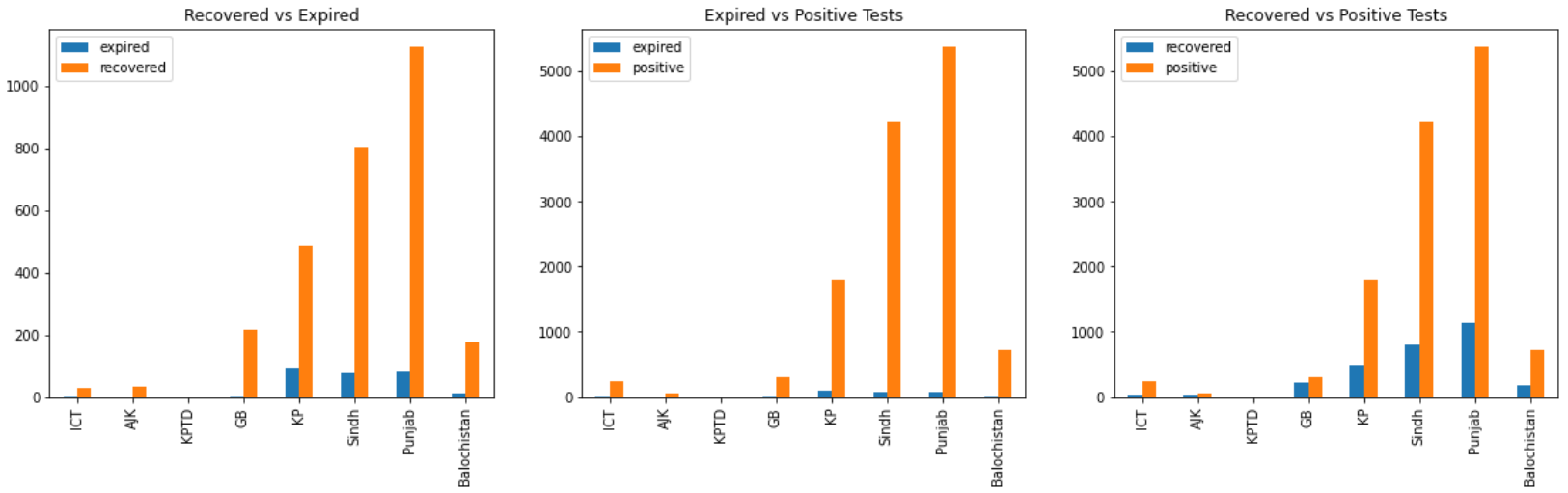



```
# comparing all the three above graphs

fig, axes = plt.subplots(nrows=1, ncols=3)

exp_rec_df.plot(kind='bar', title='Recovered vs Expired', figsize=(20,5), ax=axes[0])
exp_pos_df.plot(kind='bar', title='Expired vs Positive Tests', figsize=(20,5),ax=axes[1])
rec_pos_df.plot(kind='bar', title='Recovered vs Positive Tests',figsize=(20,5), ax=axes[2])
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f4e5d0db2e8>
```



We can see that KPTD data is almost near to none, so we are not considering KPTD In our analyses for now.

1. EXPIRED VS RECOVERED

Ranking in the decreasing order of recovered/expired ratio is:

```
1. Punjab
2. Sindh
3. KP
4. GB
5. AJK
6. Balochistan
7. ICT
```

2. EXPIRED VS POSITIVE

Ranking in the increasing order of expired/positive ratio is:

```
1. GB
2. ICT
3. Punjab
4. Balochistan
5. AJK
6. Sindh
7. KP
```

3. RECOVERED VS POSITIVE

Ranking in the decreasing order of recovered/positive ratio is:

1. GB
2. AJK
3. KP
4. Balochistan
5. Punjab
6. Sindh
7. ICT

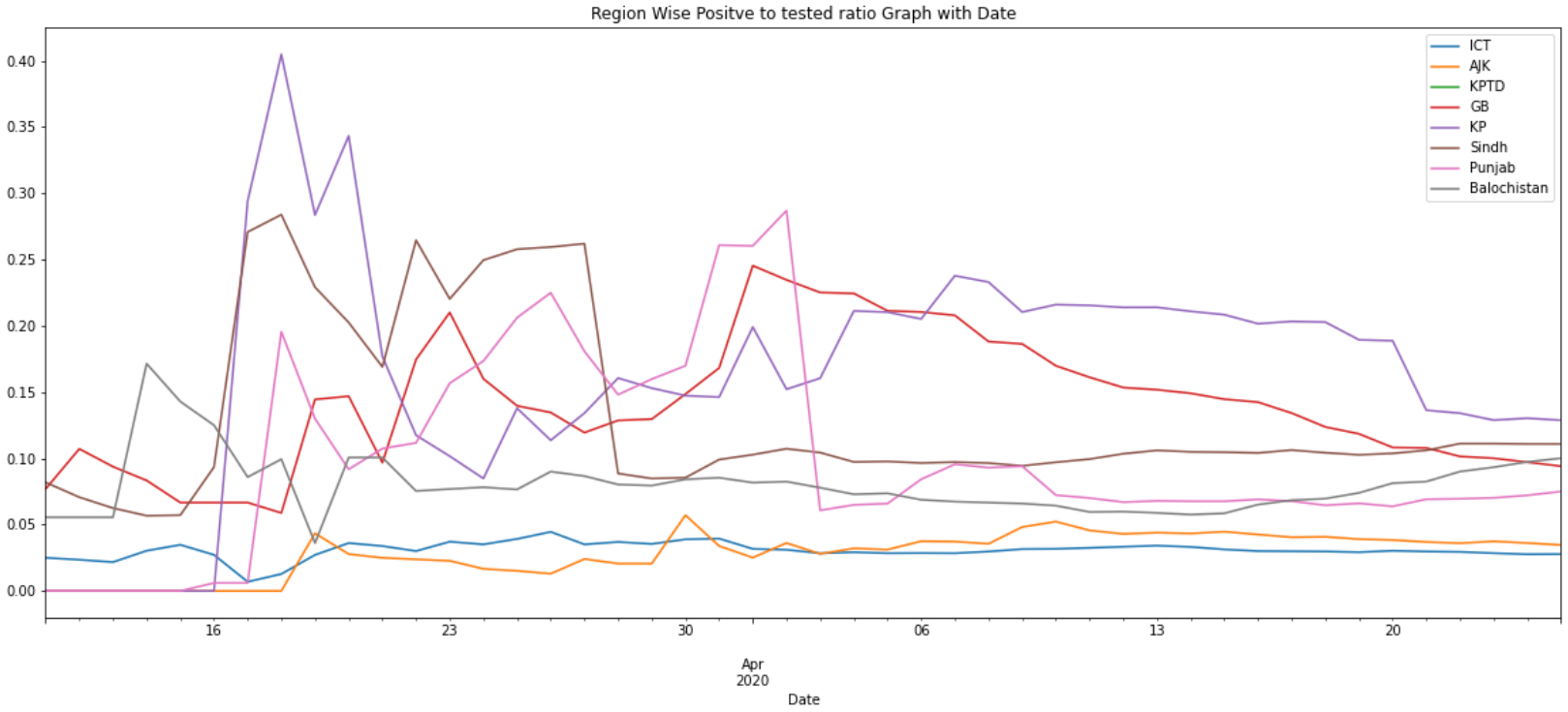
> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with top 5 regions as required.

> ***13. VISUALIZE REGION-WISE POSITVE TESTED PATIENTS OUT OF TOTAL TESTS PERFORMED WITH DATE-TIME SERIES***

```
# creating positive tested vs tests performed ratios for every region to get insights about the negative tested patients

ict['Positive Ratio']=ict['Cumulative  Test positive'].div(ict['Cumulative  tests performed'])
ajk['Positive Ratio']=ajk['Cumulative  Test positive'].div(ajk['Cumulative  tests performed'])
kptd['Positive Ratio']=kptd['Cumulative  Test positive'].div(kptd['Cumulative  tests performed'])
gb['Positive Ratio']=gb['Cumulative  Test positive'].div(gb['Cumulative  tests performed'])
kp['Positive Ratio']=kp['Cumulative  Test positive'].div(kp['Cumulative  tests performed'])
sindh['Positive Ratio']=sindh['Cumulative  Test positive'].div(sindh['Cumulative  tests performed'])
punjab['Positive Ratio']=punjab['Cumulative  Test positive'].div(punjab['Cumulative  tests performed'])
balochistan['Positive Ratio']=balochistan['Cumulative  Test positive'].div(balochistan['Cumulative  tests performed'])

# plotting Positive vs Tests Performed Ratio for every region with data
# the greater the ratio more will be the postive cases
ax = ict.plot(x ='Date', y='Positive Ratio', kind='line', figsize=(20,8), title='Region Wise Positve to tested ratio Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Positive Ratio')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Positive Ratio')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Positive Ratio')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Positive Ratio')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Positive Ratio')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Positive Ratio')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Positive Ratio')
ax.legend(["ICT", "AJK",'KPTD','GB','KP','Sindh','Punjab','Balochistan']);
```



The ranking of all the regions in the decreasing order of positive cases with time is:

1. ICT
2. AJK
3. Punjab
4. GB
5. Balochistan
6. Sindh
7. KP

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking as required.

> ***14. VISUALIZE REGION-WISE CRITICAL PATIENTS WITH DATE-TIME SERIES***

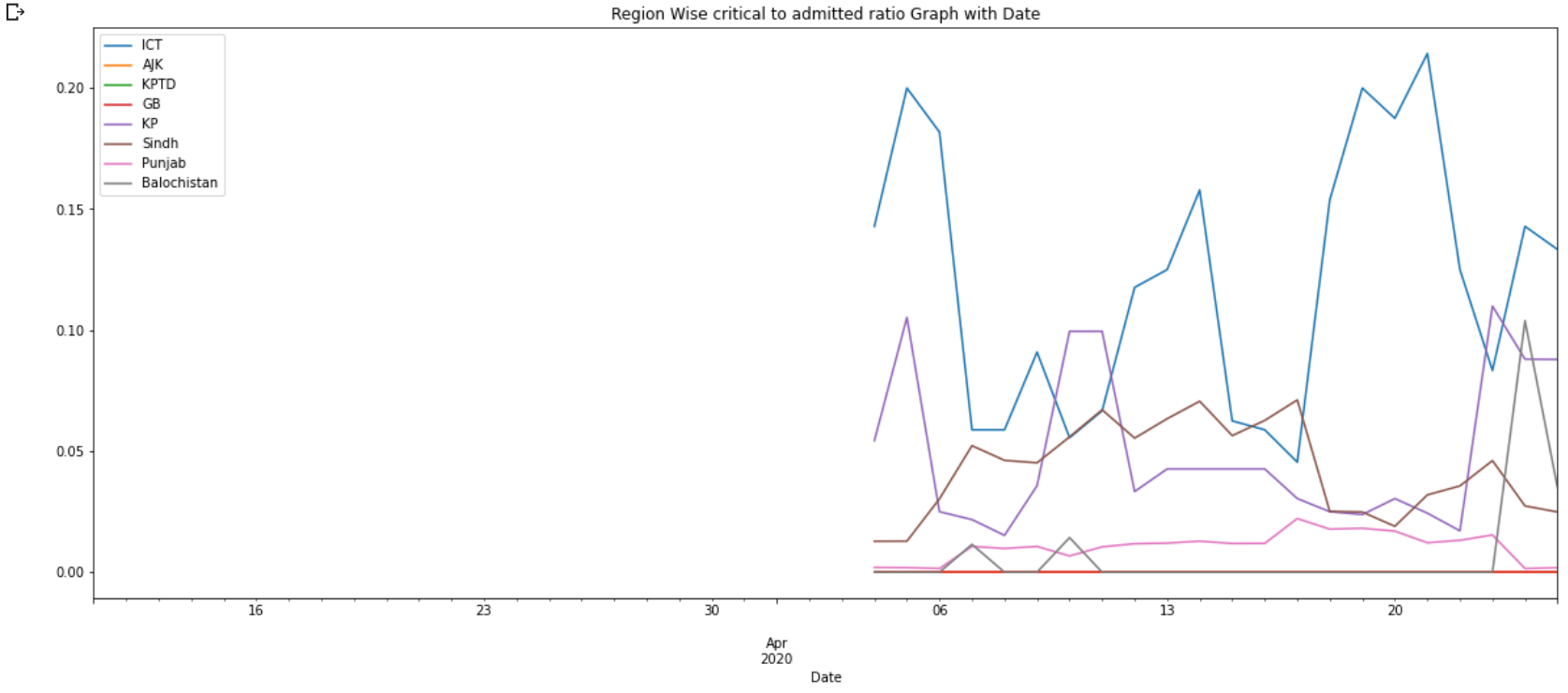
```
# creating critical patients vs total patients ratio to get the idea of critical condition trends of patients

ict['Critical Ratio']=ict['Admitted Critical'].div(ict['Total Admitted'])
ajk['Critical Ratio']=ajk['Admitted Critical'].div(ajk['Total Admitted'])
kptd['Critical Ratio']=kptd['Admitted Critical'].div(kptd['Total Admitted'])
```

```
kptd['Critical Ratio']=kptd['Admitted Critical'].div(kptd['Total Admitted'])
gb['Critical Ratio']=gb['Admitted Critical'].div(gb['Total Admitted'])
kp['Critical Ratio']=kp['Admitted Critical'].div(kp['Total Admitted'])
sindh['Critical Ratio']=sindh['Admitted Critical'].div(sindh['Total Admitted'])
punjab['Critical Ratio']=punjab['Admitted Critical'].div(punjab['Total Admitted'])
balochistan['Critical Ratio']=balochistan['Admitted Critical'].div(balochistan['Total Admitted'])


# plotting critical ratios for every region with date
# the greater ratio shows more critical situation

ax = ict.plot(x ='Date', y='Critical Ratio', kind='line', figsize=(20,8), title='Region Wise critical to admitted ratio Graph with Date')
ax1 = ajk.plot(ax=ax, x ='Date', y='Critical Ratio')
ax2 = kptd.plot(ax=ax1, x ='Date',  y='Critical Ratio')
ax3 = gb.plot(ax=ax2, x ='Date',  y='Critical Ratio')
ax4 = kp.plot(ax=ax3, x ='Date',  y='Critical Ratio')
ax5 = sindh.plot(ax=ax4, x ='Date',  y='Critical Ratio')
ax6 = punjab.plot(ax=ax5, x ='Date',  y='Critical Ratio')
ax7 = balochistan.plot(ax=ax6, x ='Date',  y='Critical Ratio')
ax.legend(["ICT", "AJK",'KPTD','GB','KP','Sindh','Punjab','Balochistan']);
```



The ranking of all the regions in the decreasing order of critical cases with time is:

1. GB
2. AJK
3. Punjab
4. Sindh
5. Balochistan
6. KP
7. ICT

> NOTE: We have ranked from best-case to worst-case as shown above. This is the current ranking, in the end we will use this in order to form a final ranking with top 5 regions as required.

INSIGHTS FROM THE ABOVE DATA ANALYSES

> We analysed the given data and we have ranked the regions with respect to their success towards COVID-19. Here are the results from the above analyses, We will consider all the analyses we did above and will rank the regions:

FREQUENCY OF REGIONS AT RESPECTIVE POSITIONS

Positions	Punjab	Sindh	Balochistan	KP	GB	AJK	ICT	KPTD (not considering due to lack of data)	SUM = no. of graphs	Max
1	5	0	0	2	2	2	3		14	Punjab
2	2	6	0	0	1	4	1		14	Sindh
3	2	2	1	6	1	1	1		14	KP
4	0	1	5	2	4	1	1		14	Balochistan
5	2	0	6	1	2	2	1		14	Balochistan
6	2	5	2	1	2	1	1		14	Sindh
7	1	0	0	2	2	3	6		14	ICT

FINAL OUTPUT

FINAL RATING

Rating	Description	Region
1	Most Successful	Punjab
2	Successful	Sindh
3	Average	KP
4	Struggling	Balochistan
5	Most Struggling	ICT