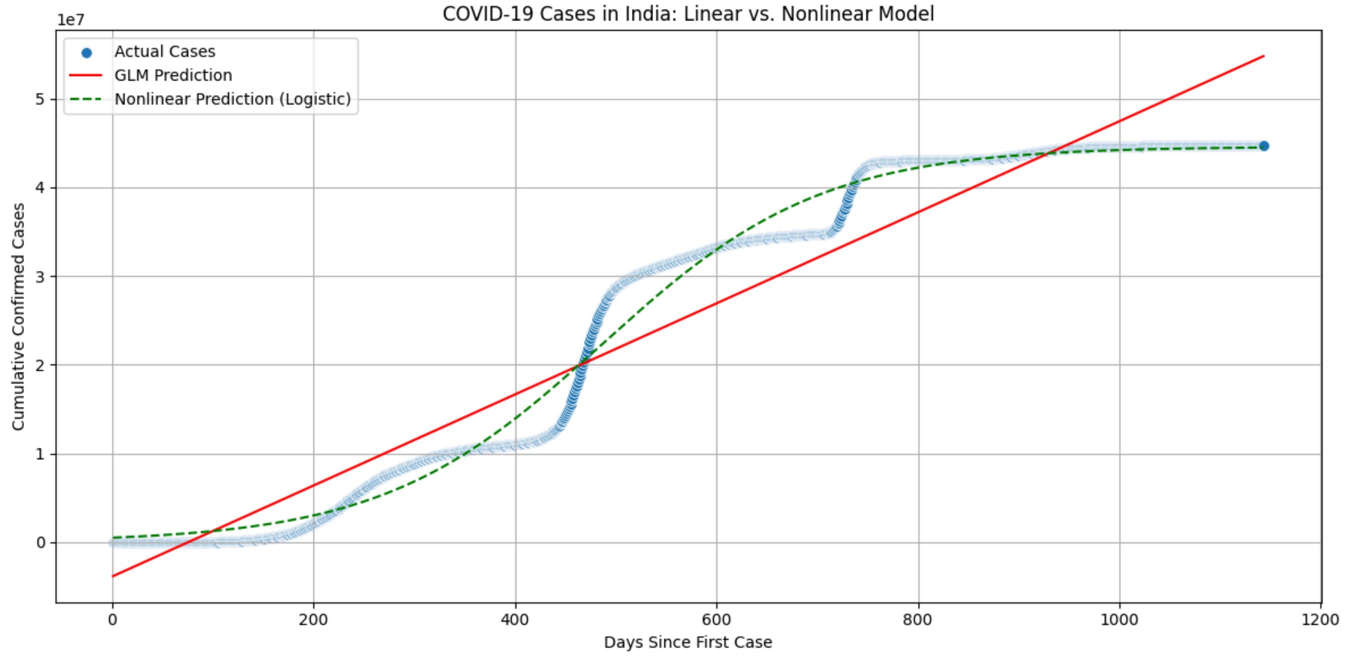
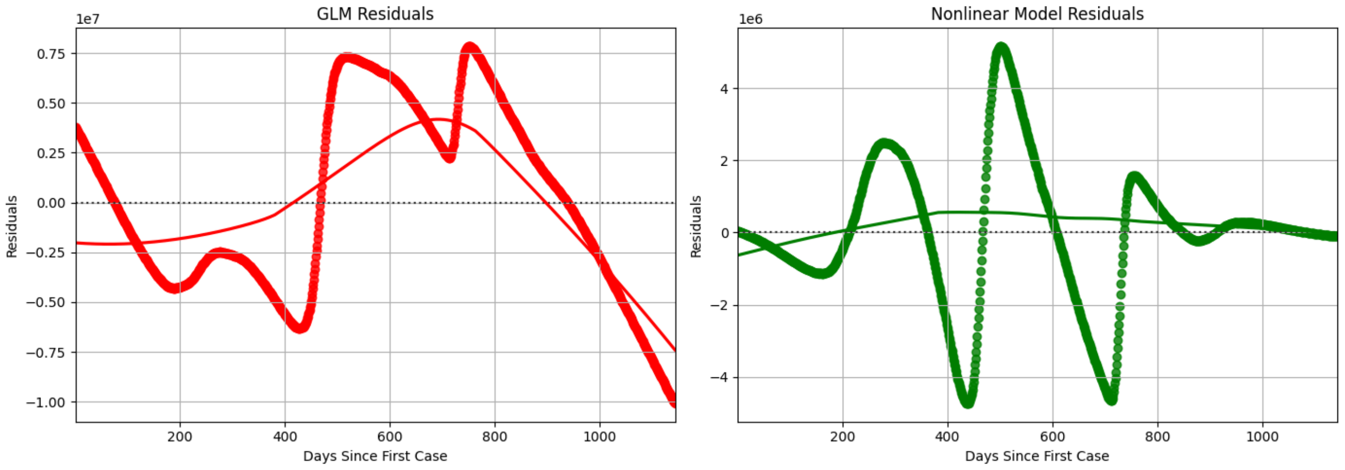
```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.optimize import curve_fit
import statsmodels.api as sm
from sklearn.metrics import mean_squared_error, r2_score

# ----------------------------
# 1. Data Acquisition and Preparation
# ----------------------------

# Load the dataset
file_path = '/content/time_series_covid19_confirmed_global.csv'
data = pd.read_csv(file_path)

# Filter for India
country = 'India'
country_data = data[data['Country/Region'] == country].iloc[:, 4:].sum().reset_index()
country_data.columns = ['Date', 'Cases']

# Convert date and calculate days since start
country_data['Date'] = pd.to_datetime(country_data['Date'])
country_data['Days'] = (country_data['Date'] - country_data['Date'].min()).dt.days + 1

# ----------------------------
# 2. Generalized Linear Model (GLM)
# ----------------------------

X_glm = sm.add_constant(country_data['Days'])  # Intercept
glm_model = sm.GLM(country_data['Cases'], X_glm, family=sm.families.Gaussian()).fit()
country_data['GLM_Pred'] = glm_model.predict(X_glm)

# ----------------------------
# 3. Nonlinear Regression - Logistic Growth Model
# ----------------------------

def logistic(x, L, x0, k):
    return L / (1 + np.exp(-k * (x - x0)))

# Initial guess: L (max), x0 (mid), k (growth rate)
p0 = [max(country_data['Cases']), np.median(country_data['Days']), 0.1]
params, _ = curve_fit(logistic, country_data['Days'], country_data['Cases'], p0=p0)
country_data['Nonlinear_Pred'] = logistic(country_data['Days'], *params)

# ----------------------------
# 4. Evaluation Metrics
# ----------------------------

glm_rmse = np.sqrt(mean_squared_error(country_data['Cases'], country_data['GLM_Pred']))
glm_r2 = r2_score(country_data['Cases'], country_data['GLM_Pred'])

nonlinear_rmse = np.sqrt(mean_squared_error(country_data['Cases'], country_data['Nonlinear_Pred']))
nonlinear_r2 = r2_score(country_data['Cases'], country_data['Nonlinear_Pred'])

print("🔹 Model Evaluation Summary")
print(f"GLM - RMSE: {glm_rmse:.2f}, R² Score: {glm_r2:.4f}")
print(f"Nonlinear - RMSE: {nonlinear_rmse:.2f}, R² Score: {nonlinear_r2:.4f}")

# ----------------------------
# 5. Visualization
# ----------------------------

plt.figure(figsize=(12, 6))
sns.scatterplot(x='Days', y='Cases', data=country_data, label='Actual Cases', s=50)
sns.lineplot(x='Days', y='GLM_Pred', data=country_data, label='GLM Prediction', color='red')
sns.lineplot(x='Days', y='Nonlinear_Pred', data=country_data, label='Nonlinear Prediction (Logistic)', color='green', linestyle='--')
plt.title(f'COVID-19 Cases in {country}: Linear vs. Nonlinear Model')
plt.xlabel('Days Since First Case')
plt.ylabel('Cumulative Confirmed Cases')
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()

# ----------------------------
# 6. Residual Analysis
# ----------------------------

country_data['GLM_Residuals'] = country_data['Cases'] - country_data['GLM_Pred']
country_data['Nonlinear_Residuals'] = country_data['Cases'] - country_data['Nonlinear_Pred']

plt.figure(figsize=(14, 5))
```

```
# GLM Residuals
plt.subplot(1, 2, 1)
sns.residplot(x='Days', y='GLM_Residuals', data=country_data, lowess=True, color='red')
plt.title('GLM Residuals')
plt.xlabel('Days Since First Case')
plt.ylabel('Residuals')
plt.grid(True)

# Nonlinear Residuals
plt.subplot(1, 2, 2)
sns.residplot(x='Days', y='Nonlinear_Residuals', data=country_data, lowess=True, color='green')
plt.title('Nonlinear Model Residuals')
plt.xlabel('Days Since First Case')
plt.ylabel('Residuals')
plt.grid(True)

plt.tight_layout()
plt.show()
```

```
<ipython-input-2-76b83123916c>:23: UserWarning: Could not infer format, so each element will be parsed individually, falling back to `da
  country_data['Date'] = pd.to_datetime(country_data['Date'])
🔹 Model Evaluation Summary
GLM - RMSE: 4756887.58, R² Score: 0.9269
Nonlinear - RMSE: 1979805.07, R² Score: 0.9873
```


COVID-19 Cases in India: Linear vs. Nonlinear Model
1e7
Actual Cases
GLM Prediction
Nonlinear Prediction (Logistic)
Cumulative Confirmed Cases
Days Since First Case


GLM Residuals
1e7
Residuals
Days Since First Case
Nonlinear Model Residuals
1e6
Residuals
Days Since First Case