#Based on Literature

S.No.	Parameter	Effect Type	Influence on Path	Reason / Explanation
1	Steering Winds (700–500 hPa)	Direct	Primary driver of path	Push cyclones along flow direction.
2	Subtropical Ridge	Direct	Blocks or redirects	High-pressure belt deflects cyclone track.
3	Coriolis Force	Direct	Curvature of path	Stronger at higher latitudes, curves NE (BoB), NW (AS).
4	Jet Streams	Direct	Can accelerate or recurve cyclone	Interaction with upper winds modifies track.
5	Monsoon Circulation	Direct	Seasonal steering	SW monsoon winds steer AS cyclones westward, BoB northeastward.
6	ENSO	Indirect	Shifts cyclone paths	Alters steering winds and shear patterns.
7	Indian Ocean Dipole (IOD)	Indirect	Strong effect on AS	Positive IOD warms AS, driving cyclones NW.
8	Madden-Julian Oscillation (MJO)	Indirect	Genesis zone shifts	Affects starting point → changes trajectory.
9	Western Disturbances	Indirect	Pulls cyclones NE	Extra-tropical interaction in BoB & N. India.
10	ITCZ Position	Indirect	Genesis & drift	Cyclones follow ITCZ belt northward.
11	Seasonality	Indirect	Pre/post-monsoon paths differ	Prevailing winds vary across seasons.
12	Land-Sea Distribution	Indirect	Attracts cyclones to low-pressure land areas	Explains frequent BoB landfalls.

13	Basin Shape	Indirect	NE path in BoB, NW in AS	Coastline + basin orientation directs landfall.
14	Topography	Indirect	Alters post-landfall direction	Deserts weaken storms, mountains deflect moisture.
15	Climate Change	Indirect	Poleward shift	Global warming modifies large-scale circulation.
16	Ocean Currents	Indirect	Small influence on drift	Currents redistribute heat and pressure gradients.

#Based on ML

Category	Parameter	Direct / Indirect	Reason for Influence on Path	Correlation with Path
Cyclone Core	Current Latitude	Direct	Defines present position, base for path forecast.	**Very High →** baseline for trajectory
	Current Longitude	Direct	Same as above, spatial reference for trajectory.	**Very High**
	Central Pressure (hPa)	Direct	Lower pressure centers steer differently in background flow.	**Medium–High**
	Maximum Wind Speed	Direct	Stronger systems resist shear and maintain momentum.	**Medium**
	Radius of Maximum Winds (RMW)	Direct	Bigger cyclones are less responsive to small-scale wind shifts.	**Medium**
Atmospheric	U-wind (500 hPa)	Direct	Zonal steering winds directly push cyclone east–west.	**Very High**
	V-wind (500 hPa)	Direct	Meridional winds push cyclone north–south.	**Very High**

	Vertical Wind Shear (200–850 hPa)	Direct	Tilts/weakens cyclone, altering track.	**Medium–High**
	Relative Humidity (700 hPa)	Indirect	Moist/dry environments support or disrupt travel.	**Low–Medium**
	Geopotential Height (500 hPa ridge)	Direct	Ridge location controls recurvature / westward drift.	**High**
	Jet Stream Winds (200 hPa)	Direct	Strong jets can pull cyclone poleward/eastward.	**High**
	Temperature Anomalies (850 & 200 hPa)	Indirect	Modulate pressure gradients → alters steering.	**Medium**
Oceanic	Sea Surface Temperature (SST)	Indirect	Sustains convection and vortex strength during travel.	**Medium**
	Ocean Heat Content (OHC)	Indirect	Deep warm water helps cyclone persist along track.	**Medium**
	Upper Ocean Salinity	Indirect	Influences thermal stratification, energy supply.	**Low**
	Ocean Currents (zonal & meridional)	Indirect	Weak but measurable drift influence.	**Low–Medium**
Climatic Indices	ENSO (Niño 3.4 index)	Indirect	Alters large-scale wind patterns globally.	**Medium**
	Indian Ocean Dipole (IOD)	Indirect	Shifts monsoon winds, changing track likelihood.	**Medium**
	Madden–Julian Oscillation (MJO phase)	Indirect	Determines convective environment → affects storm genesis & steering.	**Low–Medium**
	Seasonality (month/monsoon phase)	Indirect	Seasonal winds (monsoon vs winter) govern steering.	**Medium**

Geographical	Distance to Nearest Coastline	Direct	Determines landfall and abrupt path change.	**High**
	Land–Sea Mask	Direct	Detects whether cyclone interacts with land.	**High**
	Basin Identifier (BoB / AS / Pacific)	Indirect	Regional climatology affects steering norms.	**Medium**
	Topography of Coast (elevation)	Indirect	Can deflect flow patterns near landfall.	**Low–Medium**

#Model

1. Baseline Models

Linear Regression

- **Reason:**
    - Simple, interpretable, and fast to implement.
    - Helps establish a *minimum benchmark* to compare complex models.
    - Can capture linear relationships between features like **latitude, longitude, wind speed, and pressure**.
- **Limitation:** Cannot capture non-linear and temporal dynamics of cyclone motion.

Random Forest

- **Reason:**
    - Handles **non-linear relationships** better than regression.
    - Can rank **feature importance** (e.g., wind shear vs. SST influence).
    - Works well with tabular cyclone data (features at each timestep).

- **Limitation:** Static → treats each timestep independently (no memory of past path).

2. Sequential Models

RNN (Recurrent Neural Network)

- **Reason:**
  - Naturally suited for **time-series forecasting**.
  - Learns dependencies between cyclone's *previous track points* and the next.
- **Limitation:** Struggles with long-term dependencies (vanishing gradient problem).

LSTM (Long Short-Term Memory)

- **Reason:**
  - Designed to solve RNN limitations.
  - Retains **longer temporal memory**, which is essential because cyclone paths are influenced by conditions accumulated over hours/days.
  - Can model sequences like: *"Cyclone was moving west for 24h, now likely to recurve north-east."*

GRU (Gated Recurrent Unit)

- **Reason:**
  - Similar to LSTM but with fewer parameters → **faster training**.
  - Works well when dataset is smaller (as often with cyclone tracks).
- **Limitation:** Slightly less expressive than LSTM, but good tradeoff between complexity and performance.

3. Hybrid Models

CNN-LSTM

- **Reason:**
  - **CNN** extracts spatial features (e.g., wind patterns, SST fields, geopotential maps).
  - **LSTM** models temporal evolution (storm path over time).
  - Useful if combining **gridded ERA5 reanalysis data** with cyclone track data.

Physics-Informed ML

- **Reason:**
  - Pure ML may predict unrealistic cyclone motions (e.g., over land where physics wouldn't allow intensification).
  - Physics-informed ML adds constraints (like conservation of energy, steering winds, or Coriolis force).
  - Ensures predictions remain **scientifically consistent** with atmospheric dynamics.