Volatility-Forecasting-in-Kenya

Got it 👍 You want **everything** (intro, setup, usage, future work, etc.) under **one single Markdown file**. Here's the full **README.md** you can directly use:

```
# 📊 Volatility Forecasting in South Africa

This project explores **stock market volatility forecasting** using data from the South African financial market.
It leverages Python, machine learning, and time series models to analyze trends, forecast volatility, and gain insights into financial risks.

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## 🚀 Project Overview
Stock markets are dynamic, with prices moving constantly due to supply and demand, investor behavior, and economic factors.
This project focuses on:
- Collecting financial time series data (**open, high, low, close, volume**).
- Storing and managing data in **SQLite**.
- Implementing forecasting models (e.g., **ARIMA, GARCH, ML-based approaches**).
- Analyzing volatility patterns in the South African stock market.

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## 🛠️ Tech Stack
- **Python 3.13+**
- **SQLite** (for database management)
- **Pandas, NumPy** (data manipulation)
- **Matplotlib, Seaborn** (visualization)
- **Scikit-learn, Statsmodels** (modeling & forecasting)
- **pydantic-settings** (configuration management)

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## 📂 Project Structure
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```
Volatility-Forecasting-in-South-Africa/
│── config.py # Configuration (API keys, DB paths, etc.)
│── database.py # SQLite connection & queries
│── data_fetch.py # Fetch stock data from AlphaVantage
│── analysis.ipynb # Exploratory Data Analysis & visualizations
│── models.py # Forecasting models (ARIMA, GARCH, ML)
│── requirements.txt # Python dependencies
│── README.md # Project documentation
```

```
├── .env # API keys & sensitive credentials
├── stocks.sqlite # SQLite database (generated after fetch)
```

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## 🔑 Setup Instructions

### 1. Clone the repository
```bash
git clone https://github.com/your-username/Volatility-Forecasting-in-South-Africa.git
cd Volatility-Forecasting-in-South-Africa
```

2. Create a virtual environment

```
python -m venv venv
source venv/bin/activate   # Mac/Linux
venv\Scripts\activate      # Windows
```

3. Install dependencies

```
pip install -r requirements.txt
```

4. Configure environment variables

Create a `.env` file in the project root:

```
ALPHA_API_KEY=your_api_key_here
DB_NAME=stocks.sqlite
MODEL_DIRECTORY=models
```

5. Run the project

```
python data_fetch.py
```

📊 Example Usage

```

```
from database import Database

db = Database("stocks.sqlite")
data = db.get_stock_data("JSE") # Example for Johannesburg Stock Exchange
print(data.head())
```

☑ Features

- Fetch stock data using **AlphaVantage API**
- Store and query data in **SQLite**
- Time series forecasting using **ARIMA & GARCH**
- Visualize market trends & volatility
- Extendable to other African stock markets

🌍 Future Work

- Incorporate real-time streaming data
- Test deep learning models (**LSTM, Transformer**)
- Compare South African market with global indices
- Deploy interactive dashboards (**Plotly/Dash/Streamlit**)

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📜 License

This project is licensed under the **MIT License** - see the LICENSE file for details.

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👉 Do you also want me to **embed the dependencies (requirements.txt
content)** directly inside this README so you don’t need a separate file?
```

outout

📈 Mean–Variance Analysis: Balancing Risk and Return

This section evaluates each asset's **expected return** and **variance**, key metrics in **Modern Portfolio Theory (MPT)**.
The goal is to understand the **risk–return trade-off** and identify assets that offer the best balance between growth potential and volatility.

🧾 1. Expected Returns (Mean of Daily Returns)

Expected return represents the **average daily performance** of each asset, derived from historical price data.

Company Name	Ticker	Sector	Expected Daily Return
Bank of America	BOA	Financials	**-2.53%**
Amazon	AMZN	Technology	**+68.75%**
Shell	SHEL	Energy	**+0.79%**
Johnson & Johnson	JNJ	Healthcare	**-1.87%**
S&P 500 Index (SPJ)	SPJ	Market Index	**+0.47%**

> ⚠ These are **daily mean returns**. To estimate annual performance, multiply by the number of trading days (≈252).

📊 2. Variance of Daily Returns – Measuring Risk

Variance quantifies how much asset returns deviate from their mean — higher values indicate greater risk or volatility.

Company Name	Variance of Daily Returns	Interpretation
Bank of America	~3.92	Moderate risk
Amazon	**~1390.05**	**Extremely volatile — high risk**
Shell	~4.13	Moderate risk
Johnson & Johnson	~1.35	Low risk
S&P 500 Index (SPJ)	~4.13	Market benchmark for moderate volatility

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💬 3. Interpretation

🏆 Top Performer (Return)

- **Amazon (AMZN)** shows the **highest expected return (+68.75%)**, but its **variance is extremely high**, making it a **high-risk, high-reward** asset.

⚖ Stable, Low-Risk Assets

- **Shell (Energy)** and **Johnson & Johnson (Healthcare)** show **low to moderate variance**, indicating stability.
    - Shell's **positive return** and **manageable volatility** make it a **defensive yet profitable** asset.
    - JNJ, while low risk, shows a **negative return**, making it less attractive as a standalone investment.

▽ **Underperforming Assets**

- **Bank of America (BOA)** and **Johnson & Johnson (JNJ)** show **negative mean returns**, suggesting limited upside potential unless included for **diversification benefits**.

Market Benchmark

- **S&P 500 Index (SPJ)** provides a **modest positive return (+0.47%)** with **moderate variance**, serving as a **reference point** for performance comparison.

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4. Portfolio Implications

The Mean–Variance analysis suggests:

- **Amazon** contributes **growth potential** but increases volatility.
- **Shell** and **Johnson & Johnson** provide **stability** and help **reduce total portfolio risk**.
- Combining **low-correlation** and **moderate-risk** assets across different sectors can create an **efficient portfolio**.

Sharpe Ratio Analysis – Risk-Adjusted Performance

The **Sharpe Ratio** measures how effectively an asset compensates investors for the risk taken.
It compares each asset's **excess return** (above the risk-free rate) to its **volatility**.

> Formula:
> [
> \text{Sharpe Ratio} = \frac{R_p - R_f}{\sigma_p}
>]
> where (R_p) = average portfolio return, (R_f) = risk-free rate, and (\sigma_p) = standard deviation of returns.

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1. Computed Results

Asset (Ticker)	Expected Daily Return	Volatility (Std Dev)	Sharpe Ratio
Bank of America (BOA)	-0.0253%	1.9803%	**-0.0228**
Amazon (AMZN)	+0.6876%	37.2834%	**0.0179**
Shell (SHEL)	+0.0079%	2.0321%	**-0.0059**
Johnson & Johnson (JNJ)	-0.0187%	1.1649%	**-0.0331**

Asset (Ticker)	Expected Daily Return	Volatility (Std Dev)	Sharpe Ratio
S&P 500 Index (SPJ)	+0.0047%	2.0332%	**-0.0074**

📊 2. Interpretation

Sharpe Ratio Range	Evaluation	Meaning
> 1.0	Excellent	High returns relative to risk
0.5 – 1.0	Good	Acceptable risk-adjusted returns
0 – 0.5	Moderate	Marginal improvement over risk-free rate
< 0	Poor	Underperforming relative to risk-free rate

💡 3. Insights

- **Amazon (AMZN)** shows the **highest Sharpe Ratio (0.0179)** — although still very low, it performs *slightly better* on a risk-adjusted basis than other assets.
  However, its high volatility (37.28%) makes it risky.
- **Bank of America (BOA)** and **Johnson & Johnson (JNJ)** have **negative Sharpe Ratios**, indicating that their returns do **not** adequately compensate for risk — they underperform the risk-free benchmark.
- **Shell (SHEL)** and **S&P 500 (SPJ)** also show slightly **negative Sharpe Ratios**, meaning their daily returns are too small relative to volatility.

🧭 4. Takeaway

Current results suggest that:

- None of the assets are generating **strong risk-adjusted returns** at the daily level.
- **Amazon** remains the most promising but volatile choice.
- Combining **low-correlated** assets (from earlier covariance analysis) may **improve the overall Sharpe Ratio** through diversification.

🚀 Next Steps

To enhance portfolio performance:

- Compute a **Portfolio Sharpe Ratio** using weighted returns.
- Explore the **Efficient Frontier** to identify the **optimal mix** of assets with the highest Sharpe Ratio.
- Annualize returns and risk to provide a clearer long-term performance comparison.

🚀 Efficient Frontier & Optimal Portfolio – Maximizing Risk-Adjusted Returns

The **Efficient Frontier** represents all possible portfolios that offer the **highest expected return for a given level of risk**.
By simulating multiple weight combinations, we identify the **Optimal Portfolio** — the one that **maximizes the Sharpe Ratio**.

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1. Optimal Portfolio Summary

Metric	Value	Interpretation
Expected Daily Return	**0.0048 (≈ 0.48%)**	The portfolio's average expected daily return.
Volatility (Std Dev)	**0.2616 (≈ 26.16%)**	Indicates moderate risk — average fluctuation in daily returns.
Sharpe Ratio	**0.0177**	Measures risk-adjusted performance — the portfolio earns slightly above the risk-free rate.

> The Sharpe Ratio is relatively low at the daily level. However, annualizing returns (×252) and volatility (×√252) typically increases this value and offers a clearer long-term perspective.

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2. Interpretation

- The **Optimal Portfolio** achieves the **highest Sharpe Ratio (0.0177)** among all simulated portfolios — meaning it offers the **best trade-off between risk and return**.
- With an **expected daily return of 0.48%**, it slightly outperforms individual assets in terms of efficiency.
- **Volatility (26%)** reflects a **moderate risk exposure**, acceptable for diversified portfolios aiming for steady growth.
- Combining assets from **different sectors** (Technology, Energy, Healthcare, and Financials) reduces total variance through diversification effects.

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3. Efficient Frontier Visualization

The plot below illustrates the **Efficient Frontier**:

- **Scatter Points (Green–Yellow Gradient):** Thousands of random portfolios with different weight combinations.
- **Upper Boundary:** The Efficient Frontier — where portfolios achieve **maximum return for each risk level**.
- **Red Star (★):** The **Optimal Portfolio**, offering the **highest Sharpe Ratio**.

(See "Efficient Frontier" plot in your analysis notebook.)

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4. Key Insights

Aspect	Observation	Implication
Return vs Risk	Optimal portfolio yields moderate return for moderate risk	Balanced profile suitable for medium-risk investors
Sharpe Ratio	0.0177 → low daily but positive	Indicates improvement through diversification
Diversification Benefit	Achieved via low-correlated assets (Amazon, Shell, JNJ)	Reduces volatility without large return sacrifice

☑ 5. Strategic Takeaway

To further enhance performance:

- **Annualize the portfolio Sharpe Ratio** for realistic interpretation.
- Compare this optimal portfolio with the **market index (S&P 500)** to gauge outperformance.
- Conduct **backtesting** or **rolling Sharpe analysis** to validate consistency over time.

Portfolio Weight Optimization – Asset Allocation Strategy

This section presents the **optimal asset allocation** that achieves the **highest Sharpe Ratio**, providing the best balance between expected return and risk.

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1. Optimization Process

A **Monte Carlo simulation** of 10,000 random portfolios was performed using the assets:

- Bank of America (Financials)
- Amazon (Technology)
- Shell (Energy)
- Johnson & Johnson (Healthcare)
- S&P 500 Index (Market Benchmark)

Each simulation calculated:

- **Expected Return**
- **Portfolio Volatility**
- **Sharpe Ratio**

The portfolio with the **maximum Sharpe Ratio** was selected as the **optimal portfolio**.

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2. Optimal Weights (Example Output)

Asset	Optimal Weight (%)	Interpretation
Bank of America	10.5%	Provides financial sector exposure

Asset	Optimal Weight (%)	Interpretation
Amazon	38.2%	Growth driver, highest return potential
Shell	22.4%	Energy diversification and moderate risk
Johnson & Johnson	18.6%	Stability and defensive characteristics
S&P 500 Index	10.3%	Benchmark and broad market balance

> ⚠ *These percentages are illustrative; actual results depend on simulation output.*

📊 3. Interpretation

- The **largest weight** is allocated to **Amazon**, due to its **high expected return**.
- **Shell** and **Johnson & Johnson** provide **sectoral balance** and **volatility reduction**.
- **Bank of America** and the **S&P 500 Index** serve as **market-linked stabilizers**.
- The diversified mix reduces unsystematic risk and enhances overall **Sharpe performance**.

🧠 4. Key Takeaway

This allocation achieves the **optimal risk-adjusted performance** among all tested portfolios.
Future work can include:

- Annualized return and volatility comparison
- Dynamic rebalancing based on market trends
- Incorporating **constraints** (e.g., max weight per sector)

🧾 Optimal Portfolio Performance Summary

📊 Key Performance Metrics

Metric	Value	Interpretation
Expected Daily Return	**0.5122%**	The portfolio is expected to earn approximately **0.51% per day** on average.
Volatility (Risk)	**0.2775%**	The portfolio's daily value fluctuates by about **0.28%**, indicating **moderate risk**.
Sharpe Ratio	**1.8451**	**Excellent performance** — for every 1 unit of risk, the portfolio earns **1.85 units of excess return**.

💡 Interpretation

The optimal portfolio demonstrates **strong risk-adjusted returns**, as shown by a **Sharpe Ratio > 1.8**.
This means the portfolio efficiently balances **expected return and volatility**.

The allocation is heavily weighted toward **Amazon (74.41%)** and **Shell (17.27%)**, reflecting assets that drive higher returns while controlling for risk.
Such a portfolio is **ideal for growth-oriented investors** seeking **maximum performance** with **manageable volatility**.

Portfolio Allocation Summary

Asset	Optimal Weight (%)
Bank of America	1.89
Amazon	74.41
Shell	17.27
Johnson & Johnson	2.70
S&P 500 Index	3.73

Insights

- **High Sharpe Ratio (1.845)** → Strong risk-adjusted performance.
- **Moderate Volatility (0.28%)** → Stable daily fluctuations.
- **Amazon** is the **dominant contributor** to expected return.
- The **diversified combination** still reduces unsystematic risk.