

# BorBann

## A Real Estate Information Platform

### (Project Proposal)

by

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# Chapter 1

## Introduction

### 1.1 Background

The global real estate market shows positive growth trends despite various challenges. Real estate market remains a key sector for people like homebuyers and investors, influenced by complex characteristics with heterogeneous nature and affected by numerous elements like policies and consumer trends. The market is projected to grow from \$4,143.71 billion in 2024 to \$4,466.58 billion in 2025, and global real estate investment volumes continue to increase in 2024[1].

Thailand's real estate market faces both challenges and opportunities in the current economic climate. The real estate market in Thailand, especially in Bangkok in 2024-2025, faces challenges such as high household debt, strict credit conditions, and rising costs causing market contraction, decreasing project launches by 43.72% in 2024[2]. However, it also presents opportunities for recovery through foreign investment driven by tourism recovery, government incentives, and technological advancements. Condominiums remain attractive for rental yields and foreign buyers, while the housing market has moderate growth supported by infrastructure development.

Crucially, these market opportunities can significantly undermined by Thailand's real estate information ecosystem, which suffers from several structural limitations, including outdated listings, lack of official transaction data, and data fragmentation[3]. Addressing these issues is essential for maximizing Thailand's market potential and enabling effective decision-making for both homebuyers and investors seeking to capitalize on the available opportunities.

### 1.2 Problem Statement

Even with large amounts of real estate data available through various channels including property listings, historical transaction records, and news, investors still face challenges in aggregating, contextualizing, and deriving action from these sources. Additionally, the Thai real estate market has different characteristics from other countries because of the

limited availability of official property transaction records, listing duplication across platforms, and less standardized data compared to more mature markets.

Current platforms in Thailand like DDPProperty, Hipflat, and Baania lack many important contextual factors such as climate risk assessments, neighborhood-specific news, and local beliefs that influence property valuation and real estate investment in the long term.

While platforms like Zillow and House Canary have advanced and comprehensive real estate analytics, predictive analytics, and user-friendly interfaces, they do not operate in Thailand. Even if these advanced platforms were to enter the Thai market, they would face challenges adapting their algorithms to the local context. Their models are calibrated to markets with standardized property classifications, valuations that vary by developers, and consistent transaction data—elements that are limited in Thailand’s real estate ecosystem.

The BorBann platform addresses these challenges and aims to help users by creating a real estate data platform integrated with artificial intelligence, geospatial analytics, and data aggregation by focusing on analytics rather than transaction facilitation.

## 1.3 Solution Overview

BorBann will function as real estate data platform to users, integrating multiple data sources with advanced analytics. Below are the features and their details.

### Customizable Automated Data Integration Pipeline

- **Automated schema inference:** Analyze website structures to identify and extract key data elements
- **Field mapping:** Recognize equivalent fields across different sources (e.g., "price" vs "cost")
- **Integration framework:** Seamless connection with data export systems
- **Multi-source support:** Process data from websites, APIs, and uploaded files

### Retrain Model with Data from Pipeline

- **Custom prediction model:** Create custom prediction models by combining their pipeline data with platform data sources

### Local Contextual Analytics

- **Environmental risk assessment:** Evaluate flood risk, natural disaster vulnerability, and air quality
- **Facility proximity analysis:** Calculate accessibility to schools, hospitals, transit, and commercial centers

- **Neighborhood quality scoring:** Generate composite metrics for area evaluation

## Explainable Price Prediction Model

- **Feature importance analysis:** Quantify and rank factors influencing property prices
- **Adjustable characteristics modeling:** Adjust property characteristics to visualize price impacts
- **Confidence intervals:** Provide lower/upper price bounds for realistic expectations
- **Factor categorization:** Group influences by type (property features, location, market trends)
- **Natural language explanations:** Generate readable summaries of price determinants
- **Visual breakdowns:** Display contribution percentages and relationship graphs

## Geospatial Visualization

- **Heatmap generation:** Create density visualizations for environmental factors, pricing, and metrics
- **Geospatial analytics:** Calculate analytics for custom geographic areas

## 1.4 Target User

| User Type                    | Description                                                                                      | Needs                                                                                                                                 |
|------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Real Estate Investors</b> | Individuals focused on maximizing long-term investment, including foreign investors              | <ul style="list-style-type: none"> <li>• Investment analysis</li> <li>• Supporting data for decision making</li> </ul>                |
| <b>Homebuyers</b>            | First-time purchasers, residents looking to relocate within Thailand, and expats seeking housing | <ul style="list-style-type: none"> <li>• Property comparisons</li> <li>• Neighborhood insights</li> <li>• Pricing guidance</li> </ul> |

Table 1.1: Target Users and Their Needs

## 1.5 Benefit

The BorBann platform will provide numerous benefits to the Thai real estate market. It improves market transparency by enhancing accessibility to market information. It also helps both homebuyers and investors reduce research time, achieve lower transaction risks, and discover overlooked investment opportunities. Additionally, the platform will effectively represent the unique characteristics of the Thai real estate market.

## 1.6 Terminology

| Term                            | Definition                                                                                                                                       |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Local Analytics</b>          | Analysis focused on extremely specific geographic areas, such as neighborhoods or even individual streets, to provide highly relevant insights.  |
| <b>Price Prediction Model</b>   | An algorithm or statistical model that forecasts property values based on historical data, market trends, and various property characteristics.  |
| <b>Proximity Analysis</b>       | The study of spatial relationships between geographic features, typically to evaluate the distance between properties and amenities or services. |
| <b>Geospatial Visualization</b> | The graphical representation of data with a geographic or spatial component, often through maps and interactive displays.                        |

Table 1.2: Terminology

# Chapter 2

## Literature Review and Related Work

This chapter presents a review of existing platforms in the domain of real estate analytics and information systems. This review includes both international and Thai platforms, their features, strengths, and limitations. The analysis establishes the current state of real estate information platforms and identifies opportunities for the BorBann platform to address unmet needs in the Thai market.

### 2.1 Competitor Analysis

Many real estate platforms primarily function as property listing aggregators rather than comprehensive information systems. Their features support transaction facilitation through showcasing available properties, while offering limited analytical tools for market understanding. However, platforms like House Canary represent exceptions, operating specifically as information systems that provide investors with data analytics and market insights to support evidence-based decision-making in real estate investments.

| Feature                                          | BorBann<br>(Proposed) | DDProperty | Hipflat | House<br>Canary                  | Zillow                           |
|--------------------------------------------------|-----------------------|------------|---------|----------------------------------|----------------------------------|
| Customizable Automated Data Integration Pipeline | Yes                   | No         | No      | No                               | No                               |
| Retrain Model with Data from Pipeline            | Yes                   | No         | No      | No                               | No                               |
| Local Contextual Analytics                       | Yes                   | No         | No      | Yes (Not optimized for Thailand) | Yes (Not optimized for Thailand) |
| Explainable Price Prediction Model               | Yes                   | No         | No      | No                               | No                               |
| Geospatial Visualization                         | Yes                   | Yes        | Yes     | Yes                              | Yes                              |

Table 2.1: Feature Comparison: BorBann vs Other Platforms

Table 2.1 demonstrates BorBann's technical advantages in the real estate analytics market. While all platforms offer geospatial visualization, BorBann's implementation includes advanced analytics like climate assessment, matching international platforms but

surpassing local Thai competitors. BorBann’s automated data integration pipeline collects analytics-ready data automatically, unlike Thai platforms that rely on user inputs. Also, user can use that data to create their custom models. For local contextual analytics, BorBann provides Thailand-optimized insights including weather patterns and population density, whereas DDProperty/Hipflat only show basic nearby facilities, and international platforms lack Thailand-specific optimization. Most distinctively, BorBann’s price prediction model prioritizes explainability and interpretability, revealing the reasoning behind valuations rather than presenting opaque predictions like competing platforms.

| Technical Aspect         | DDProperty                     | Hipflat                        | House Canary     | Zillow                           | BorBann (Proposed)           |
|--------------------------|--------------------------------|--------------------------------|------------------|----------------------------------|------------------------------|
| <b>Data Sources</b>      | User-submitted,<br>Proprietary | User-submitted,<br>Proprietary | Proprietary      | Multiple Sources,<br>Proprietary | Open Data,<br>User-submitted |
| <b>ML Implementation</b> | Basic Prediction               | None                           | Black-box Models | Black-box Models                 | Explainable Models           |

Table 2.2: Comprehensive Technical Comparison

Table 2.2 highlights key technical differences between BorBann and competing platforms. For data sources, while competitors rely heavily on government or user-submitted data, BorBann uniquely leverages open data combined with APIs to build a more comprehensive dataset. Regarding machine learning, BorBann distinguishes itself by implementing explainable models, providing transparency in its predictions. This contrasts with DDProperty’s basic prediction capabilities, Hipflat’s complete lack of ML features, and the black-box approaches of House Canary and Zillow where prediction logic remains hidden from users.

# Chapter 3

## Requirement Analysis

### 3.1 Stakeholder Analysis

The stakeholder landscape for BorBann includes primary stakeholders who directly interact with the platform and secondary stakeholders who indirectly influence its adoption and effectiveness. Recognizing these groups' specific needs helps develop a platform that delivers value across the real estate ecosystem.

| Stakeholder Category | Stakeholder Group     | Key Interests                                                           | Primary Requirements                                                                |
|----------------------|-----------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Primary              | Real Estate Investors | Environment risk assessment                                             | Advanced analytics, predictive modeling, risk scoring                               |
| Primary              | Homebuyers            | Affordability, area quality, lifestyle alignment, environmental factors | User-friendly interface, neighborhood insights, price comparisons, risk assessments |
| Secondary            | Real Estate Agencies  | Market positioning, client advisement, property valuation               | Property data, reliable market insights                                             |

Table 3.1: BorBann Platform Stakeholder Summary

The primary stakeholders are direct users who rely on BorBann's capabilities for informed real estate decisions. Their requirements range from investment analytics to intuitive neighborhood quality assessments. Secondary stakeholders like real estate agencies can influence platform adoption and serve as valuable data partners.

### Primary Stakeholders

Primary stakeholders are those who directly use or are significantly affected by the BorBann platform. They rely on its capabilities to make informed decisions about real estate investments, purchases, and market trends.

## Real Estate Investors

Real estate investors use BorBann to identify profitable investment, assess risks, and make data-driven decisions.

### Interests and Concerns:

- Maximizing return on investment
- Identifying growth areas
- Risk assessment
- Diversification across neighborhoods and property classes

### Requirements:

- Advanced analytics tools that is customizable
- Predictive price modeling with easy to understand explanation
- Risk scores in each area based on multiple factors

## Homebuyers

Homebuyers rely on BorBann to find properties that align with their budget, lifestyle, and long-term needs. The platform helps them assess affordability, neighborhood quality, and potential risks.

### Interests and Concerns:

- Property affordability and financing options
- Area quality
- Location amenities and lifestyle alignment
- Environmental factors including flood and pollution risks
- Commute time to work, schools, and essential services
- School districts and educational quality

### Requirements:

- Intuitive, user-friendly interface with minimal learning curve
- Comprehensive neighborhood insights including safety metrics
- Price comparison tools with historical context

- Property quality and developer reputation metrics
- Detailed flood risk and environmental quality assessment
- Transit accessibility maps with time-based visualizations
- Education quality indicators and school zone mapping

## Secondary Stakeholders

Secondary stakeholders are indirectly impacted by the BorBann platform, influencing its adoption, data availability, and overall market reach.

### Real Estate Agencies

Real estate agencies act as intermediaries between property buyers and sellers. They use BorBann to improve their advisory services, gain a competitive edge, and provide market insights to clients.

#### Interests and Concerns:

- Market positioning relative to competitors
- Client advisement based on reliable data
- Access to comprehensive property information
- Accurate property valuation to support transactions

#### Influence:

- Potential data partners and platform promoters
- Can significantly influence adoption rates among clients
- May provide valuable transaction data not available elsewhere

## 3.2 User Stories

User stories capture the essential needs and goals of the BorBann platform's target users from their perspective. These stories follow the standard format: "As a [user type], I want to [action/feature] so that [benefit/value]."

Table 3.2: User Stories with Acceptance Criteria

| User Story                                                                                                                                                                      | Acceptance Criteria                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Customizable Automated Data Integration Pipeline</b>                                                                                                                         |                                                                                                                                                                                                                  |
| As a non-technical user, I want to input a website URL and have the system automatically generate a scraping configuration, so I can collect data without coding skills         | <ul style="list-style-type: none"> <li>System provides visual confirmation of detected data structure</li> <li>Non-technical users can successfully create a working pipeline in under 5 minutes</li> </ul>      |
| As a user, I want to paste multiple URLs from the same website pattern and have the system recognize the common structure, so I can efficiently collect data from similar pages | <ul style="list-style-type: none"> <li>System identifies common patterns across multiple URLs from the same website</li> <li>A single configuration works for all provided URLs from the same pattern</li> </ul> |
| As a user, I want to upload data files (CSV, JSON) as alternative data sources to integrate with my scraped data                                                                | <ul style="list-style-type: none"> <li>System accepts uploads of CSV and JSON files up to 50MB</li> <li>Automatic schema detection for uploaded files with 90% accuracy</li> </ul>                               |
| As a user, I want to customize the output format and template via an intuitive UI                                                                                               | <ul style="list-style-type: none"> <li>User can select from at least 4 output formats (JSON, CSV, SQLite, YAML)</li> <li>UI provides visual preview of output format before confirmation</li> </ul>              |
| As a user, I want to schedule my data pipeline to run automatically at specified intervals                                                                                      | <ul style="list-style-type: none"> <li>Interface allows setting schedule frequency (hourly, daily, weekly, monthly)</li> <li>Timezone selection is available for scheduling</li> </ul>                           |

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Table 3.2 – Continued from previous page

| User Story                                                                                          | Acceptance Criteria                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| As a user, I want a dashboard showing all my data pipelines with their status and last run time     | <ul style="list-style-type: none"> <li>• Dashboard displays all pipelines with status indicators</li> <li>• Last run time and next scheduled run are clearly shown</li> </ul>                                       |
| <b>Local Contextual Analytics</b>                                                                   |                                                                                                                                                                                                                     |
| As a user, I can see all contextual data for specific areas to make informed decisions              | <ul style="list-style-type: none"> <li>• System displays at least 5 contextual data points for any selected area</li> <li>• Historical trends for environmental factors available for at least 12 months</li> </ul> |
| As a user, I want to see flood risk assessments for properties with historical flooding data        | <ul style="list-style-type: none"> <li>• Flood risk presented on a 5-point scale with historical context</li> <li>• System shows flood history for the past 10 years when available</li> </ul>                      |
| As a user, I want to see daily air quality metrics around a property with historical trends         | <ul style="list-style-type: none"> <li>• Air quality index displayed with daily updates</li> <li>• Historical air quality data presented in trend graphs</li> </ul>                                                 |
| As a user, I want to see all schools within a custom radius, including distance, ratings, and types | <ul style="list-style-type: none"> <li>• System displays all schools within user-defined radius</li> <li>• Each school listing includes distance, type, and quality rating</li> </ul>                               |

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Table 3.2 – Continued from previous page

| User Story                                                                                                | Acceptance Criteria                                                                                                                                                                                    |
|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| As a user, I want to view healthcare facilities near a property with distance and service information     | <ul style="list-style-type: none"> <li>Healthcare facilities categorized by type (hospital, clinic, etc.)</li> <li>Distance and basic service information provided for each facility</li> </ul>        |
| <b>Explainable Price Prediction Model</b>                                                                 |                                                                                                                                                                                                        |
| As a user, I want to see how specific contextual factors influence the property's predicted price         | <ul style="list-style-type: none"> <li>System displays top 5 factors influencing price with percentage contribution</li> <li>Visual indicators show positive/negative impact of each factor</li> </ul> |
| As a user, I want the model to be interpretable so I can understand factors affecting the price           | <ul style="list-style-type: none"> <li>Plain language explanations accompany each prediction</li> <li>Interactive elements allow exploration of factor relationships</li> </ul>                        |
| As a user, I want a statement or reason to back the prediction so I can trust the system's valuation      | <ul style="list-style-type: none"> <li>Each prediction includes at least 3 specific supporting statements</li> <li>System indicates confidence level for each prediction</li> </ul>                    |
| As a user, I want to see a predicted price range for any property I select                                | <ul style="list-style-type: none"> <li>System shows lower and upper bounds for predicted price</li> </ul>                                                                                              |
| As a user, I want to understand how the model derives the result so I can explain the valuation to others | <ul style="list-style-type: none"> <li>System provides visual breakdown of prediction process</li> </ul>                                                                                               |
| <b>Geospatial Visualization</b>                                                                           |                                                                                                                                                                                                        |

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Table 3.2 – Continued from previous page

| User Story                                                                                                | Acceptance Criteria                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| As a user, I can see property listings on the map and click them to view detailed information             | <ul style="list-style-type: none"> <li>Property details popup appears within 1 second of clicking a marker</li> <li>Popup contains at least 5 key property attributes</li> </ul>               |
| As a user, I can see sections of the same property group to identify properties from the same development | <ul style="list-style-type: none"> <li>Properties from same development visually grouped with distinct boundaries</li> <li>Group name appears when hovering over grouped properties</li> </ul> |
| As a user, I can see multiple map visualization types to analyze different environmental factors          | <ul style="list-style-type: none"> <li>System offers at least 5 different visualization overlays</li> <li>Users can toggle between visualizations without page reload</li> </ul>               |
| As a user, I want to pan and zoom on an interactive property map to explore different areas efficiently   | <ul style="list-style-type: none"> <li>Map responds to standard pan/zoom gestures within 100ms</li> <li>Property markers adjust density based on zoom level</li> </ul>                         |
| As a user, I want to set a custom radius around a point on the map to analyze the surrounding area        | <ul style="list-style-type: none"> <li>User can place and adjust analysis radius on any map location</li> <li>Contextual analytics update in real-time as radius is moved</li> </ul>           |

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**Retrain Model with Data from Pipeline**

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Table 3.2 – Continued from previous page

| User Story                                                                                                 | Acceptance Criteria                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| As a non-technical user, I want to select one of my existing data pipelines as a source for model training | <ul style="list-style-type: none"> <li>• User can select any active pipeline as a data source through a simple dropdown</li> <li>• System validates data compatibility before starting training process</li> </ul>    |
| As a user, I want to select from recommended model types appropriate for my data                           | <ul style="list-style-type: none"> <li>• System suggests optimal model types based on data characteristics</li> <li>• Each model type includes a simple explanation of its strengths and use cases</li> </ul>         |
| As a user, I want to start the model training process with a single click after selecting my data sources  | <ul style="list-style-type: none"> <li>• Training begins with a single action after configuration</li> <li>• System provides confirmation that training has started</li> </ul>                                        |
| As a user, I want to see how accurate my trained model is compared to platform default models              | <ul style="list-style-type: none"> <li>• Performance metrics displayed with comparative benchmark against standard models</li> <li>• Visualizations show improvement or differences in prediction accuracy</li> </ul> |
| As a user, I want to activate my newly trained model with a single click to apply it across the platform   | <ul style="list-style-type: none"> <li>• Model activation changes system behavior immediately</li> <li>• Visual indicator shows which model is currently active</li> </ul>                                            |

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Table 3.2 – Continued from previous page

| User Story                                                                                             | Acceptance Criteria                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| As a user, I want to see a list of all models I've trained with performance metrics and creation dates | <ul style="list-style-type: none"> <li>• Management interface displays all user models with key metadata</li> <li>• Models can be sorted and filtered by different attributes</li> </ul>             |
| As a user, I want to receive clear explanations if my pipeline data is unsuitable for training         | <ul style="list-style-type: none"> <li>• System provides specific feedback about data quality issues</li> <li>• Suggestions for data improvements are provided when problems are detected</li> </ul> |

### 3.3 Use Case Diagram

The Use Case Diagram for the BorBann platform, shown in Figure 3.1, illustrates the primary interactions between the system and its three main user types: Real Estate Investors, Homebuyers, and Property Developers. The diagram captures the core functionality of the platform and how different users interact with its features.

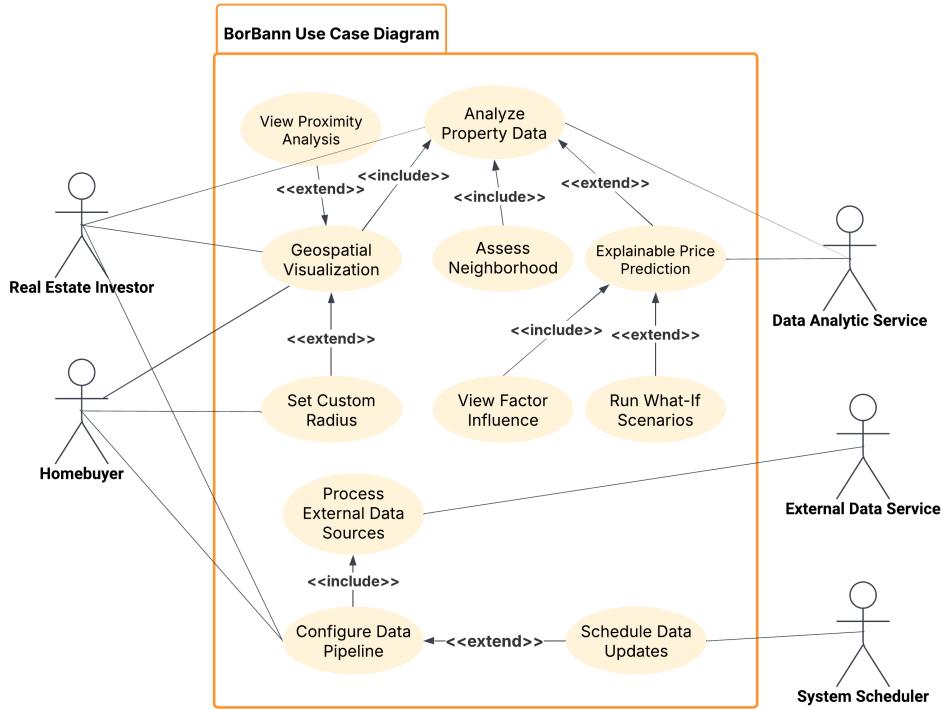


Figure 3.1: Use Case Diagram

### Primary Actors

The use case diagram identifies five key actors interacting with the BorBann system:

- **Real Estate Investor** Seeks in-depth property analytics, market trends, and investment decision support.
- **Homebuyer** Interested in residential properties, lifestyle factors, and long-term value.
- **Data Analytic Service** Provides analytic capabilities to support prediction and data analysis features.
- **External Data Service** Supplies third-party data inputs via APIs and other integrations.

- **System Scheduler** Automates routine system tasks such as scheduled data refresh operations.

## Core Use Cases

The BorBann platform provides the following primary functionalities:

- **Analyze Property Data** Allows users to examine detailed property information, metrics, and comparisons.
  - *Includes:* Assess Neighborhood
  - *Extended by:* Explainable Price Prediction
- **Geospatial Visualization** Interactive map-based visualization of property and neighborhood data.
  - *Extended by:* Set Custom Radius, View Proximity Analysis
- **Assess Neighborhood** Evaluates contextual factors around properties (e.g., schools, amenities).
  - *Includes:* View Factor Influence
  - *Extended by:* Check Environmental Risks
- **Explainable Price Prediction** AI-generated pricing insights with interpretable influencing factors.
  - *Includes:* View Factor Influence
- **Configure Data Pipeline** Enables setup of automated ingestion of external data from APIs and sources.
  - *Includes:* Process External Data Sources
  - *Extended by:* Schedule Data Updates

## Extended Functionality

The following optional use cases extend the platform's functionality:

- **View Proximity Analysis** Triggered when users want detailed proximity-based data (e.g., nearby schools, transport).
- **Set Custom Radius** Adds user-defined range settings for map-based filtering and analysis.
- **Schedule Data Updates** Automates periodic refreshes of data pipelines using system scheduler logic.
- **Check Environmental Risks** Enables users to access data on environmental threats (e.g., flood zones, pollution).

## Actor-System Interactions

Each actor interacts with the system in distinct ways, as shown in the diagram:

- **Real Estate Investor**
  - Initiates *Analyze Property Data*, *Geospatial Visualization*, and *Configure Data Pipeline*
  - Benefits from extended insights like *Set Custom Radius*, *View Proximity Analysis*, and *Explainable Price Prediction*
- **Homebuyer**
  - Accesses *Analyze Property Data*, *Geospatial Visualization*, *Assess Neighborhood*, and *Explainable Price Prediction*
  - Makes use of neighborhood-specific features like *View Factor Influence* and *Check Environmental Risks*
- **Data Analytic Service**
  - Collaborates with the system to enable *Explainable Price Prediction*
- **External Data Service**
  - Supports *Process External Data Sources* as part of the data ingestion workflow
- **System Scheduler**
  - Triggers *Schedule Data Updates* as an automated background process

## Use Case Relationships

- <<include>> Represents mandatory sub-functions:
  - *View Factor Influence* is included in both *Assess Neighborhood* and *Explainable Price Prediction*
  - *Process External Data Sources* is included in *Configure Data Pipeline*
- <<extend>> Represents optional or conditional behavior:
  - *Set Custom Radius* and *View Proximity Analysis* extend *Geospatial Visualization*
  - *Check Environmental Risks* extends *Assess Neighborhood*
  - *Schedule Data Updates* extends *Configure Data Pipeline*

## 3.4 Use Case Model

The Use Case Model details the interactions depicted in the Use Case Diagram, describing each use case within BorBann's core features.

| <b>Use Case Name</b>      | <b>View Property Insights</b>                                                                                                                                                                                                                                                                                                                                                |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Actors</b>             | Real Estate Investor, Homebuyer, Property Developer                                                                                                                                                                                                                                                                                                                          |
| <b>Description</b>        | Provides users with comprehensive analytics and contextual information about specific properties                                                                                                                                                                                                                                                                             |
| <b>Preconditions</b>      | User has selected a property from search results                                                                                                                                                                                                                                                                                                                             |
| <b>Basic Flow</b>         | <ol style="list-style-type: none"> <li>1. User selects a property for detailed viewing</li> <li>2. System retrieves comprehensive property data</li> <li>3. System presents property details with analytics</li> <li>4. System displays neighborhood characteristics</li> <li>5. System shows historical performance metrics</li> <li>6. User reviews information</li> </ol> |
| <b>Alternative Flows</b>  | <ul style="list-style-type: none"> <li>• User can extend to save the property as a favorite</li> <li>• User can extend to view explainable price predictions</li> <li>• User can request additional specific analytics</li> </ul>                                                                                                                                            |
| <b>Postconditions</b>     | User gains comprehensive insights about the property                                                                                                                                                                                                                                                                                                                         |
| <b>Associated Feature</b> | Local Contextual Analytics - providing trend analysis and neighborhood-specific insights                                                                                                                                                                                                                                                                                     |

Table 3.3: View Property Insights Use Case

| Use Case Name             | Explainable Price Prediction                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Actors</b>             | Real Estate Investor, Homebuyer                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Description</b>        | Provides transparent, interpretable price predictions with detailed explanations of contributing factors                                                                                                                                                                                                                                                                                                                         |
| <b>Preconditions</b>      | User is viewing property insights                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Basic Flow</b>         | <ol style="list-style-type: none"> <li>1. User requests price prediction for a property</li> <li>2. System calculates predicted price using its models</li> <li>3. System generates explanation of factors influencing the prediction</li> <li>4. System presents prediction with confidence interval</li> <li>5. System displays factor weights and their impact</li> <li>6. User reviews prediction and explanation</li> </ol> |
| <b>Alternative Flows</b>  | <ul style="list-style-type: none"> <li>• User can adjust factors to see impact on prediction</li> <li>• User can compare prediction with market averages</li> <li>• User can save prediction for future reference</li> </ul>                                                                                                                                                                                                     |
| <b>Postconditions</b>     | User understands the predicted price and the reasoning behind it                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Associated Feature</b> | Explainable Price Prediction Model - providing transparent explanations for price predictions                                                                                                                                                                                                                                                                                                                                    |

Table 3.4: Explainable Price Prediction Use Case

## 3.5 User Interface Design

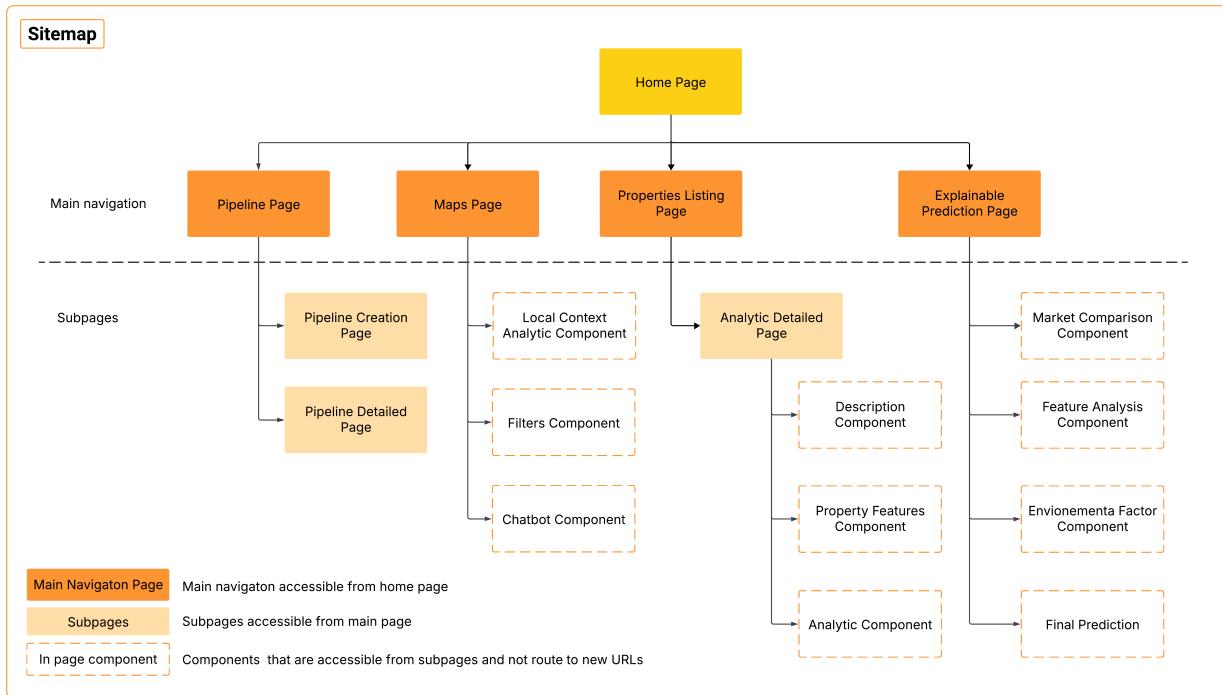


Figure 3.2: Sitemap - Platform Structure Overview

Figure 3.2 shows the structure of the BorBann platform. The Home Page acts as the central access point leading to four main sections: Pipeline, Maps, Properties Listing, and Explainable Prediction pages.

Each main section connects to specific subpages. The Pipeline section includes Creation and Detailed pages. The Maps section features Local Context Analytics, Filters, and Chatbot components. The Properties section provides Analytic Detailed pages with Description, Property Features, and Analytics components. The Explainable Prediction section offers Market Comparison, Feature Analysis, Environmental Factor analysis, and Final Prediction components.

This structure organizes the platform's key functions in a logical flow, making it easy for users to navigate between data management, visualization, and prediction features.

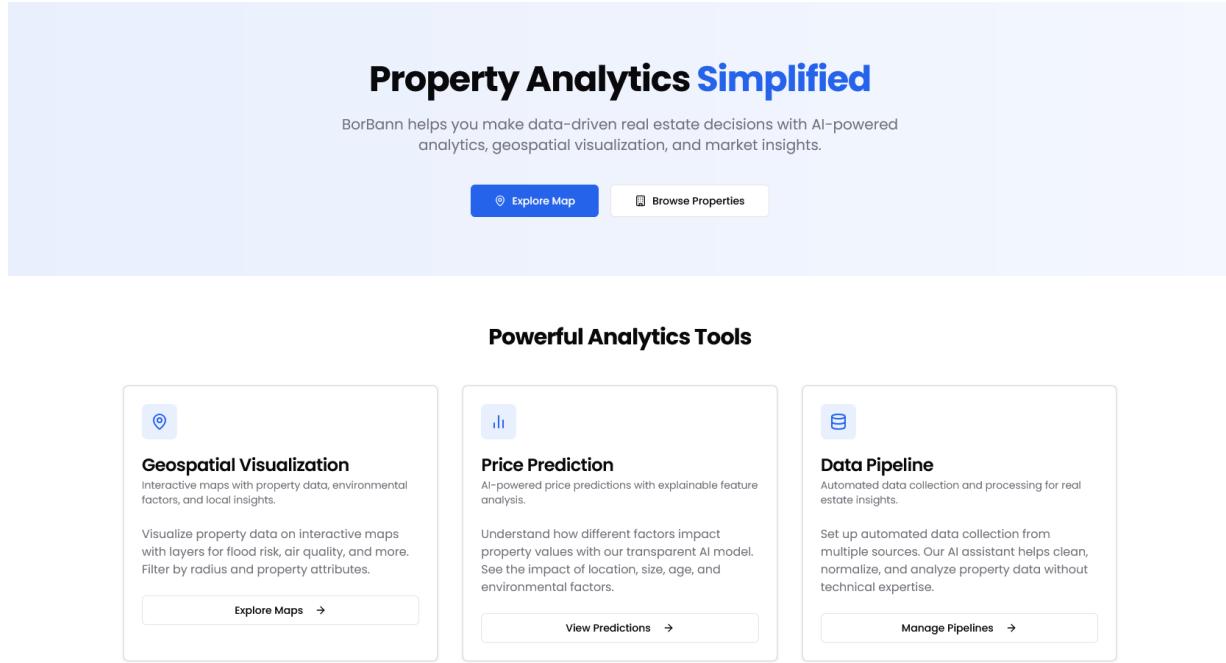


Figure 3.3: BorBann Platform Homepage

Figure 3.3 shows the BorBann platform homepage, which provides an intuitive entry point to the system. The page presents the core value proposition with "Property Analytics Simplified" and briefly explains how BorBann helps users make data-driven real estate decisions through analytics, geospatial visualization, and market insights. Two primary action buttons - "Explore Map" and "Browse Properties" - enable quick access to key functionality. The lower section showcases three main analytics tools: Geospatial Visualization for interactive property mapping, Price Prediction with explainable AI features, and Data Pipeline for automated data collection and processing.

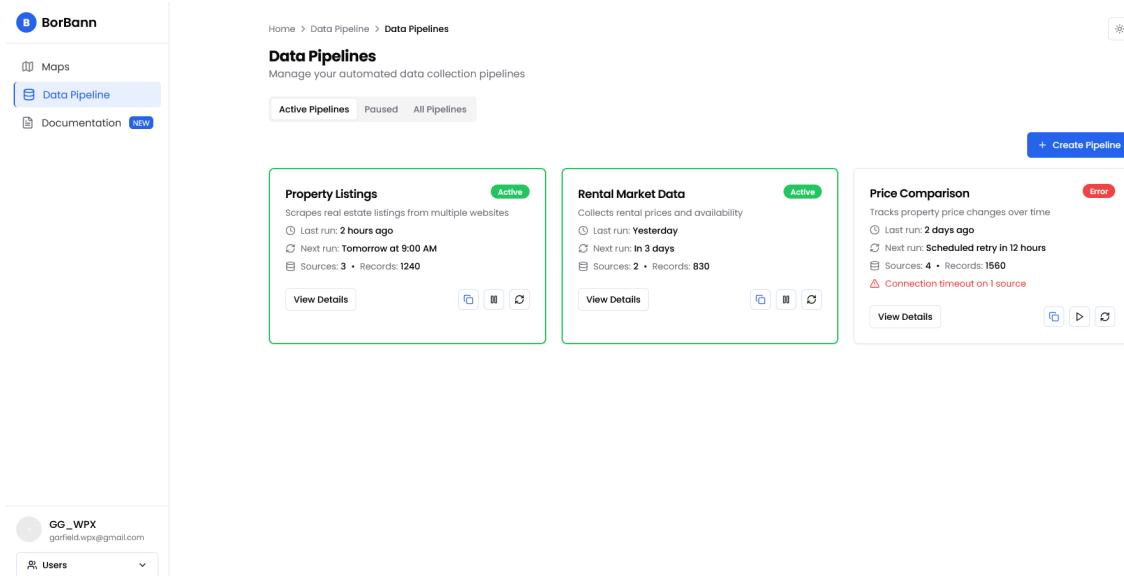


Figure 3.4: Data Pipeline Management Interface

Figure 3.4 showcases the Data Pipeline management dashboard, providing users with comprehensive control over their automated data collection processes. The interface features intuitive navigation with filtering options for Active, Paused, and All Pipelines, enabling efficient workflow management.

Each pipeline card presents essential operational metrics including last run timestamp, next scheduled execution, number of data sources, and total records processed. This at-a-glance view allows users to quickly assess data freshness and monitor collection performance across multiple pipelines.

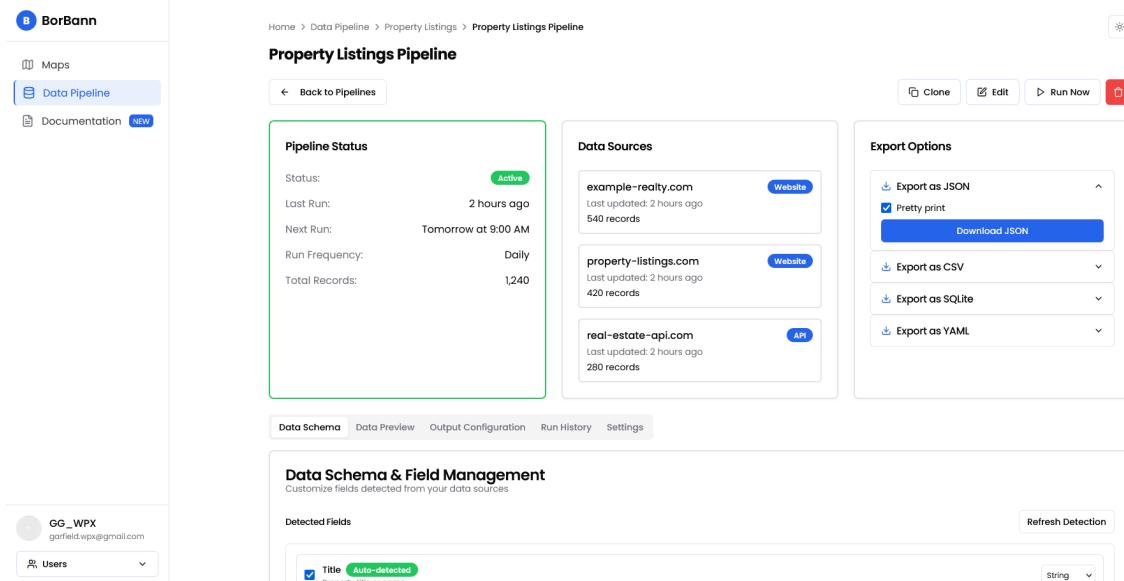


Figure 3.5: Data Integration Pipeline Detail - Overview

Figure 3.5 illustrates the pipeline detail view, highlighting key operational components including current status indicators, connected data sources, and available export formats. This overview provides users with immediate visibility into pipeline configuration and functionality.

The screenshot shows the 'Field Management' section of a data integration pipeline. On the left, there's a sidebar with 'BorBann' logo, 'Maps', 'Data Pipeline' (which is selected), and 'Documentation'. Below the sidebar is a user profile for 'GG\_WPX' (garfield.wpx@gmail.com). The main area is titled 'Customize fields detected from your data sources'. It has two sections: 'Detected Fields' and 'Derived Fields'. In 'Detected Fields', there are five entries: 'Title' (Auto-detected, String), 'Price' (Auto-detected, Number), 'Location' (Auto-detected, String), 'Bedrooms' (Auto-detected, Number), and 'Bathrooms' (Auto-detected, Number). Each entry includes a checkbox and a description. There's also a link to 'Add custom field'. In 'Derived Fields', there's one entry: 'Price Per Square Foot' (Derived), with the formula 'price / squareFeet'. A 'Create calculated fields' section is also present. At the bottom right are 'Reset to Default' and 'Save Field Configuration' buttons.

Figure 3.6: Data Integration Pipeline Detail - Field Management

Figure 3.6 displays the field management section of the pipeline detail page. This interface empowers users to customize their data structure by managing output fields and creating derived fields through a visual formula builder. Users can transform raw data into meaningful metrics without writing code.

The screenshot shows the 'Output Data Preview' tab. At the top, there are tabs for 'Data Schema', 'Data Preview' (which is selected), 'Output Configuration', 'Run History', and 'Settings'. The 'Data Preview' section is titled 'Sample of the collected data'. It contains a table with columns: ID, Title, Price, Bedrooms, Bathrooms, Location, and Sq. Ft. The table has three rows of data:

| ID   | Title            | Price       | Bedrooms | Bathrooms | Location    | Sq. Ft. |
|------|------------------|-------------|----------|-----------|-------------|---------|
| P001 | Modern Apartment | \$350,000   | 2        | 2         | Downtown    | 1,200   |
| P002 | Luxury Villa     | \$1,250,000 | 5        | 4         | Suburbs     | 3,500   |
| P003 | Cozy Studio      | \$180,000   | 1        | 1         | City Center | 650     |

Figure 3.7: Data Integration Pipeline Detail - Output Data Preview

Figure 3.7 presents the data preview tab, where users can examine sample records generated by their pipeline. This real-time preview functionality allows users to validate data quality and structure before export or analysis.

**Output Configuration**  
Configure how your data will be structured and exported

**Output Format**

- JSON**  
Structured data format
- CSV**  
Spreadsheet compatible
- SQLite**  
Portable database
- YAML**  
Human-readable format

**Format Preview**

```
{
  "properties": [
    {
      "id": "P001",
      "title": "Modern Apartment",
      "price": 350000,
      "bedrooms": 2,
      "location": "Downtown"
    },
    {
      "id": "P002",
      "title": "Luxury Villa",
      "price": 1250000,
      "bedrooms": 5,
      "location": "Suburbs"
    }
  ]
}
```

**Sample Data**

**Export Data**

Figure 3.8: Data Integration Pipeline Detail - Export Configuration

Figure 3.8 shows the export configuration interface, where users can precisely define output schemas for their data exports. This tab enables users to select specific fields, customize formatting, and choose from multiple export formats to meet their downstream requirements.

**Run History**  
History of pipeline executions

| Run ID  | Date                 | Status               | Duration | Records | Actions         |
|---------|----------------------|----------------------|----------|---------|-----------------|
| RUN-I23 | Today, 10:30 AM      | <span>Success</span> | 2m 15s   | 1,240   | <b>View Log</b> |
| RUN-I22 | Yesterday, 10:30 AM  | <span>Success</span> | 2m 10s   | 1,235   | <b>View Log</b> |
| RUN-I21 | 2 days ago, 10:30 AM | <span>Success</span> | 2m 05s   | 1,228   | <b>View Log</b> |

Figure 3.9: Data Integration Pipeline Detail - Run History

Figure 3.9 displays the run history tab, providing a chronological log of pipeline executions. This audit trail includes execution timestamps, duration metrics, and status indicators, enabling users to monitor performance trends and troubleshoot any execution issues.

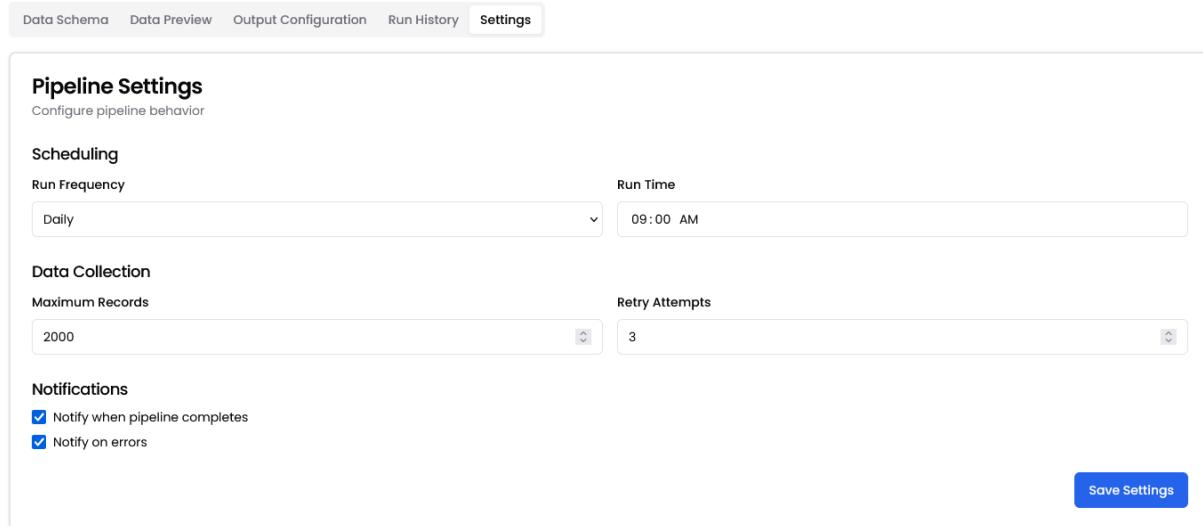


Figure 3.10: Data Integration Pipeline Detail - Pipeline Settings

Figure 3.10 illustrates the pipeline settings tab, where users can configure automation parameters including execution schedules, notification preferences, and retry policies. These controls allow users to establish reliable data collection routines that align with their operational requirements.

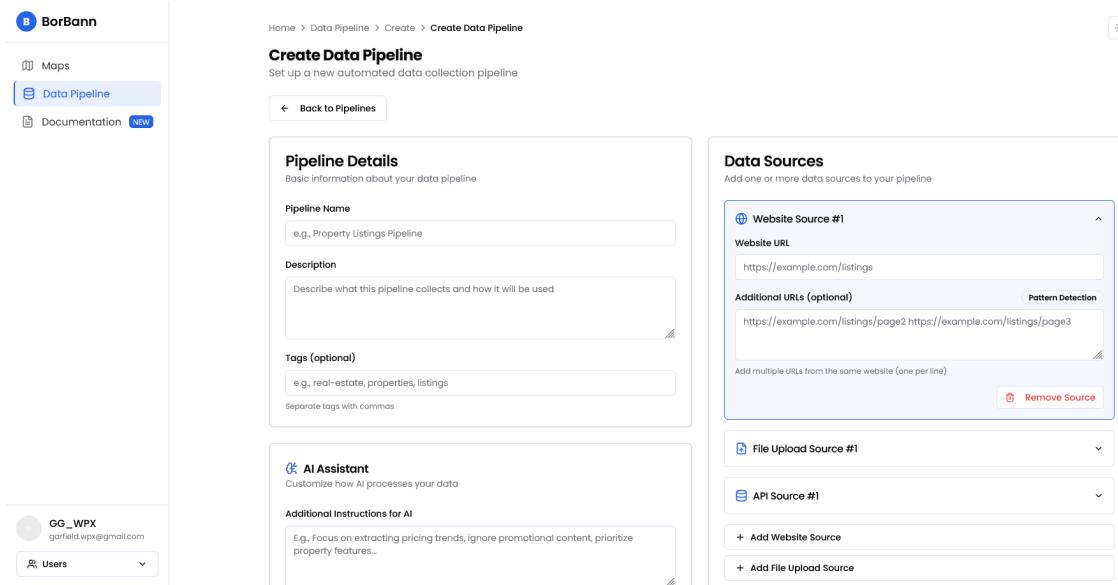


Figure 3.11: Data Integration Pipeline - Creation Interface

Figure 3.11 shows the pipeline creation interface where users input website URLs for automated data extraction. The form enables non-technical users to configure scraping operations without coding knowledge.

Figure 3.12 displays automation settings for pipeline execution with scheduling options and AI-assisted extraction configuration. Users can set run frequency and notification

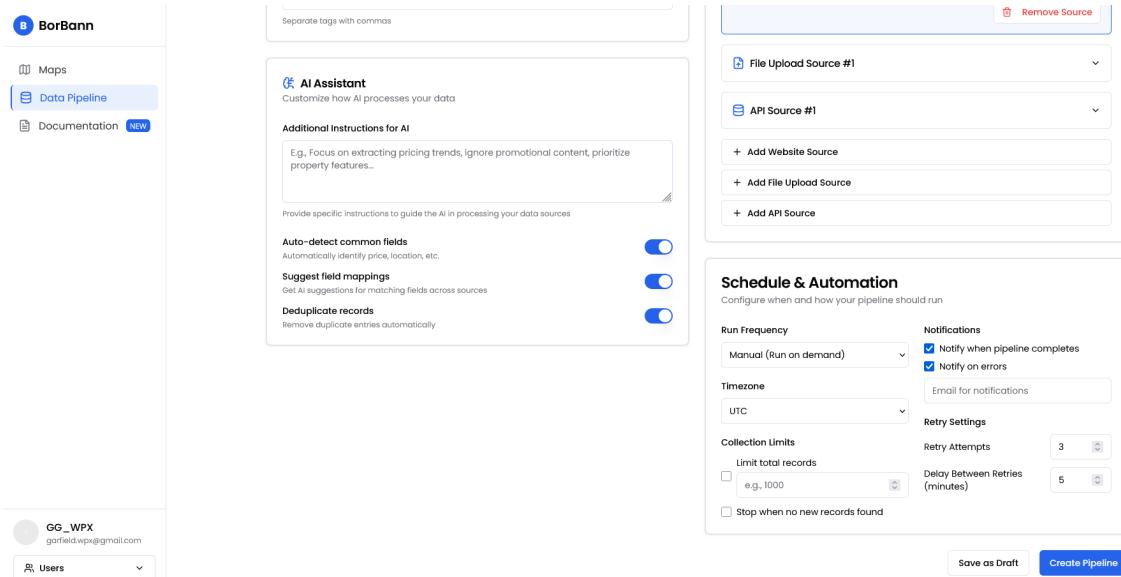


Figure 3.12: Data Integration Pipeline - Advanced Configuration and Scheduling

preferences to maintain automated data collection.

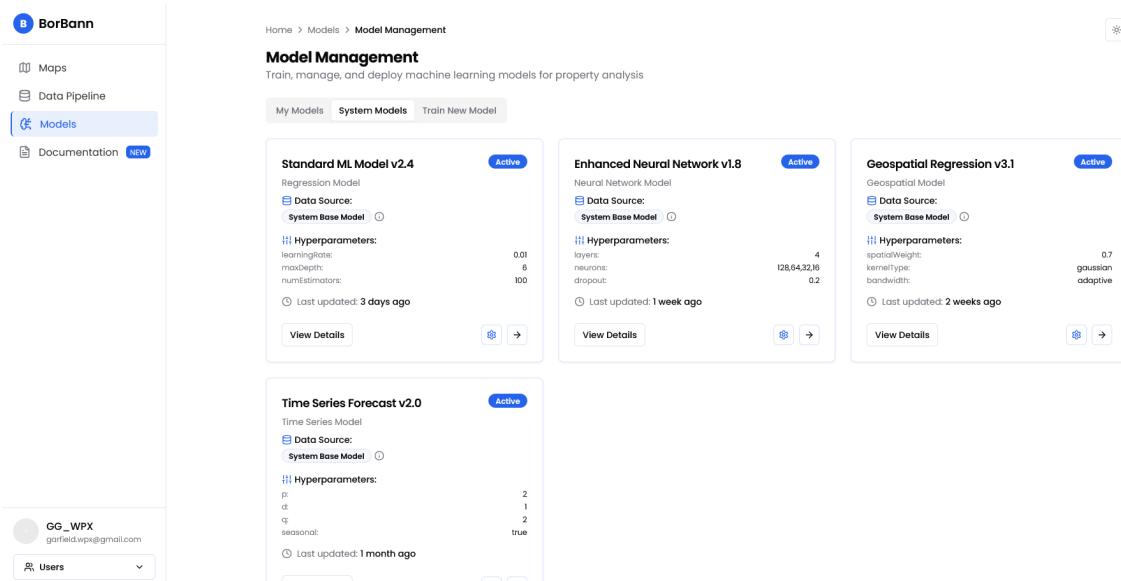


Figure 3.13: Model Management Dashboard

Figure 3.13 presents the model management dashboard where users can view and control prediction models. The interface displays performance metrics and allows single-click model activation.

Figure 3.14 shows the model creation interface for configuring new prediction models. Users can select data pipelines as training sources and choose from recommended algorithms with explanations of their strengths.

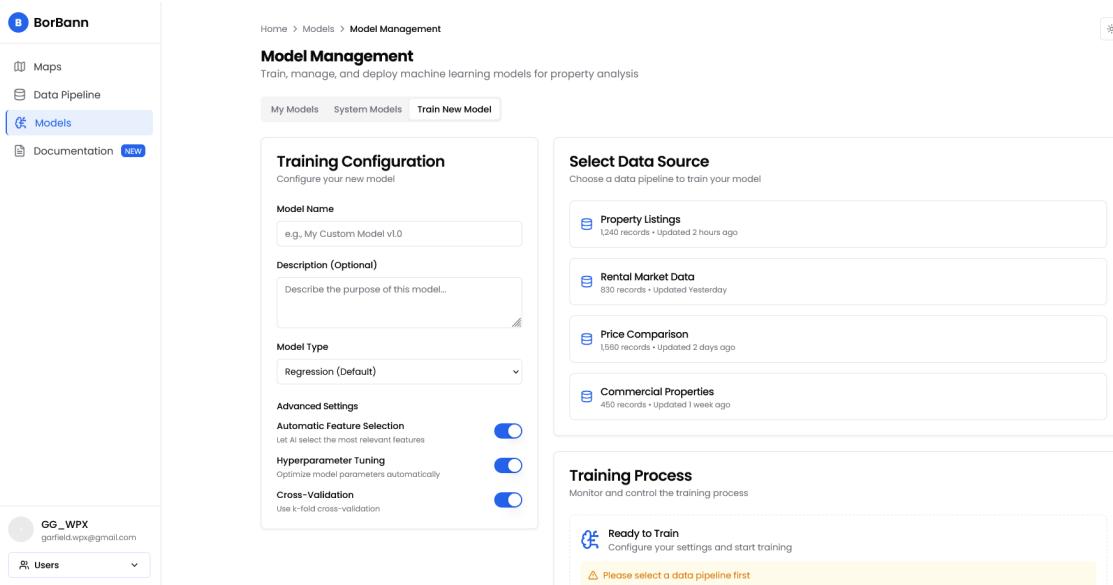


Figure 3.14: Model Creation Interface

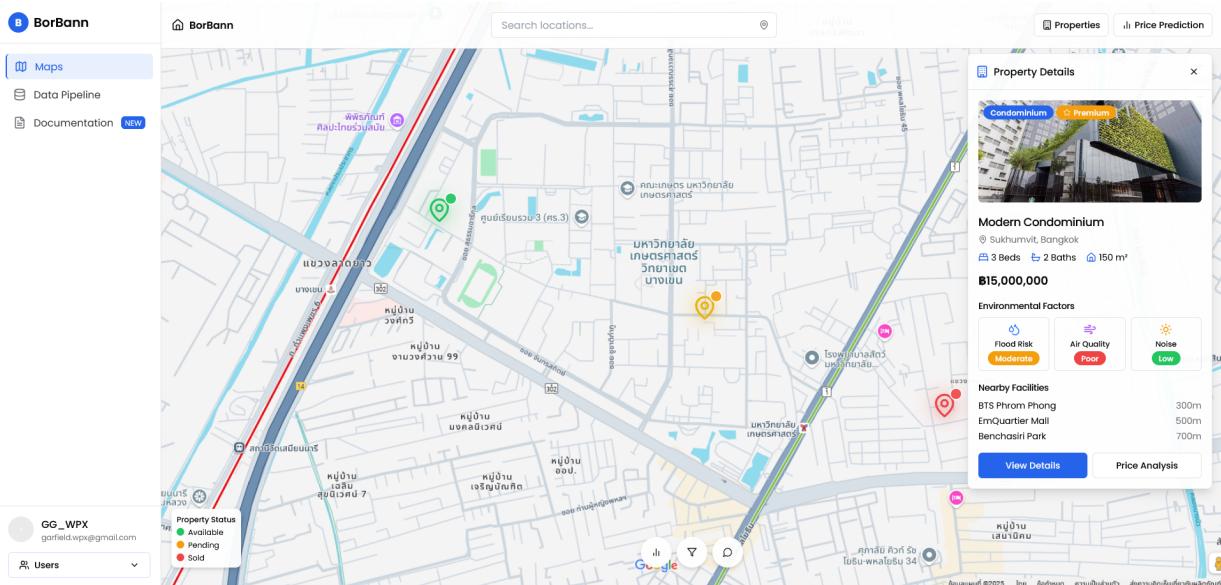


Figure 3.15: Geospatial Visualization - Main Map Interface

Figure 3.15 displays the interactive property map with color-coded markers and navigation controls. The interface supports pan/zoom gestures and provides filtering options through the sidebar.

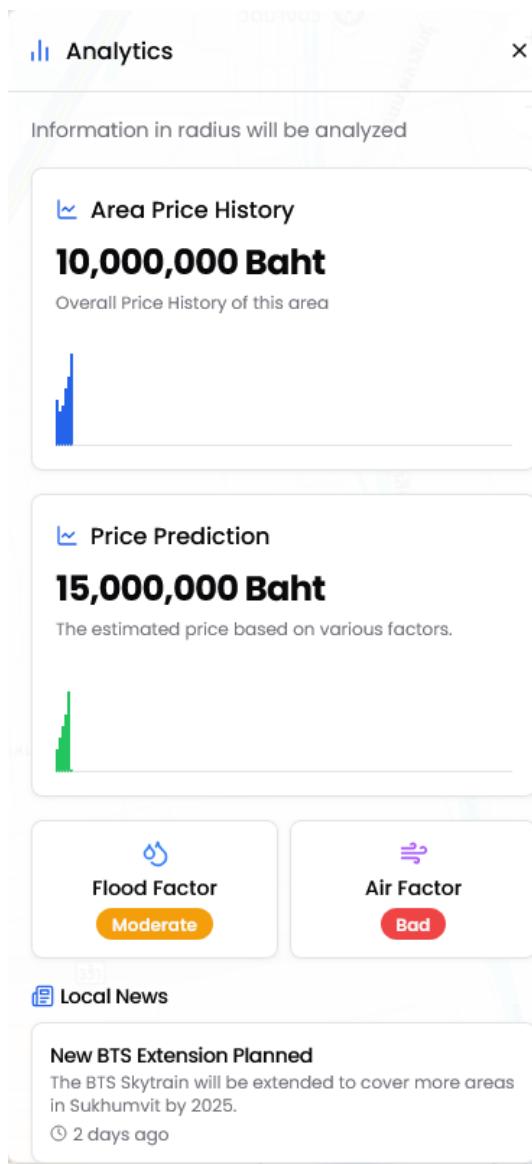


Figure 3.16: Map Analytics Overlay

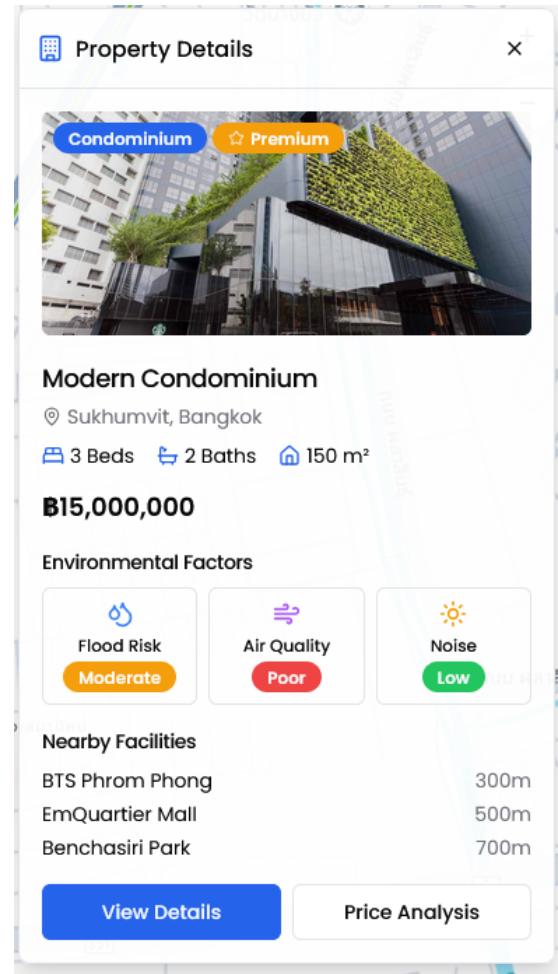


Figure 3.17: Property Detail Overlay

Figure 3.16 shows environmental factor visualization through heat maps and data layers. This overlay helps users analyze contextual factors like pollution levels directly on the map.

Figure 3.17 displays the popup that appears when users click map markers. This overlay provides immediate property information without requiring navigation away from the map.

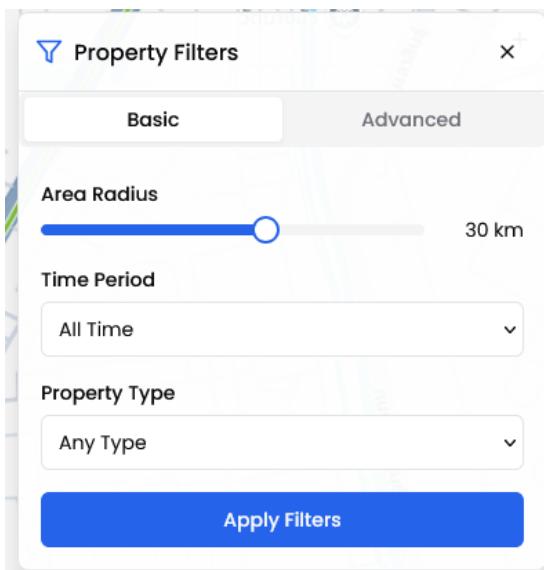


Figure 3.18: Property Filter Panel

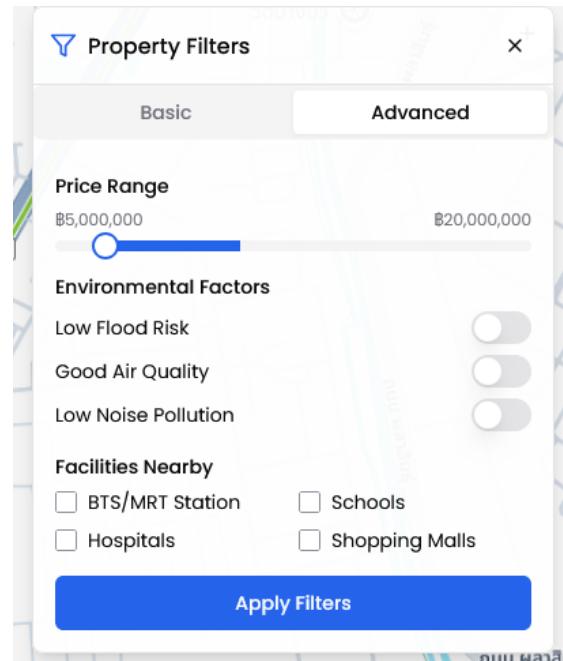


Figure 3.19: Advanced Property Filter Options

Figure 3.18 shows basic property filtering controls for price range, type and size parameters. The panel uses sliders and checkboxes for intuitive refinement of map results.

Figure 3.19 displays extended filtering options for specific amenities and neighborhood characteristics. These advanced parameters enable precise property matching based on detailed criteria.

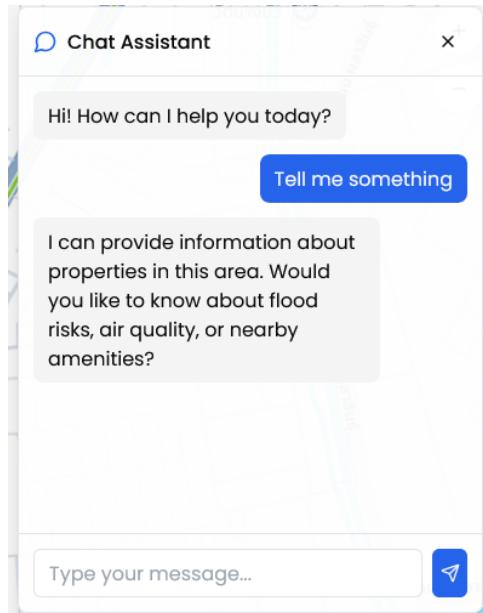


Figure 3.20: Interactive Chatbot Assistant

Figure 3.20 shows the conversational assistant for property search and analysis. The chatbot handles natural language queries about properties and market conditions.

The screenshot shows the 'Explainable Price Prediction Model' interface. On the left, a sidebar includes links for 'Maps', 'Data Pipeline', 'Models', and 'Documentation'. A user profile 'GG\_WPX garfield.wpx@gmail.com' is shown. The main content area has tabs for 'Property Details', 'Feature Analysis', 'Market Comparison', and 'Environmental Factors'. Under 'Property Details', it lists: Type (Condominium), Size (150 sqm), Bedrooms (3), Bathrooms (2), Age (5 years), and Floor (15). The 'Feature Analysis' tab is active, showing a summary: 'Our AI model begins by analyzing the core attributes of your property. These fundamental characteristics form the baseline for our prediction.' It includes sections for 'Property Type' (Condominium properties in this area have specific market dynamics), 'Size & Layout' (150 sqm with 3 bedrooms and 2 bathrooms), 'Property Age' (Built 5 years ago, affecting depreciation calculations), and 'Floor & View' (Located on floor 15, impacting value and desirability). A dropdown menu on the right lists models: 'Standard ML Model v2.4' (selected), 'Standard ML Model v2.4', 'Enhanced Neural Network v1.8', 'Geospatial Regression v3.1', 'Time Series Forecast v2.0', and 'Custom Model (User #1242)'. A 'Manage Models...' button is also present. A 'Next Step' button is at the bottom right.

Figure 3.21: Explainable Price Prediction - Property Overview

Figure 3.21 displays the initial analysis of property attributes in the prediction model. The interface includes interactive parameter sliders that show how changes to property characteristics affect the predicted price.

The screenshot shows the 'Explainable Price Prediction Model' interface with the 'Feature Analysis' tab selected. The left sidebar and property details are identical to Figure 3.21. The 'Feature Analysis' section contains a chart titled 'How different features impact the predicted price'. It shows the percentage impact of various factors: Location (+35%), Size (+25%), Age (-15%), Amenities (+10%), Floor (+8%), and Air Quality (-7%). Below the chart, a 'Key Insights' box lists: 'Location is the strongest factor, contributing +35% to the price', 'The property's size (150 sqm) positively impacts the valuation', 'The age of the property (5 years) has a moderate negative impact (-15%)', 'Poor air quality in the area reduces the value by 7%', and 'High floor (15) adds a premium of 8% to the property value'. A 'Next Step' button is at the bottom right.

Figure 3.22: Explainable Price Prediction - Feature Importance Visualization

Figure 3.22 shows the contribution of different property features to the predicted price. The visualization uses color-coded bars to differentiate positive and negative factors with percentage impact values.

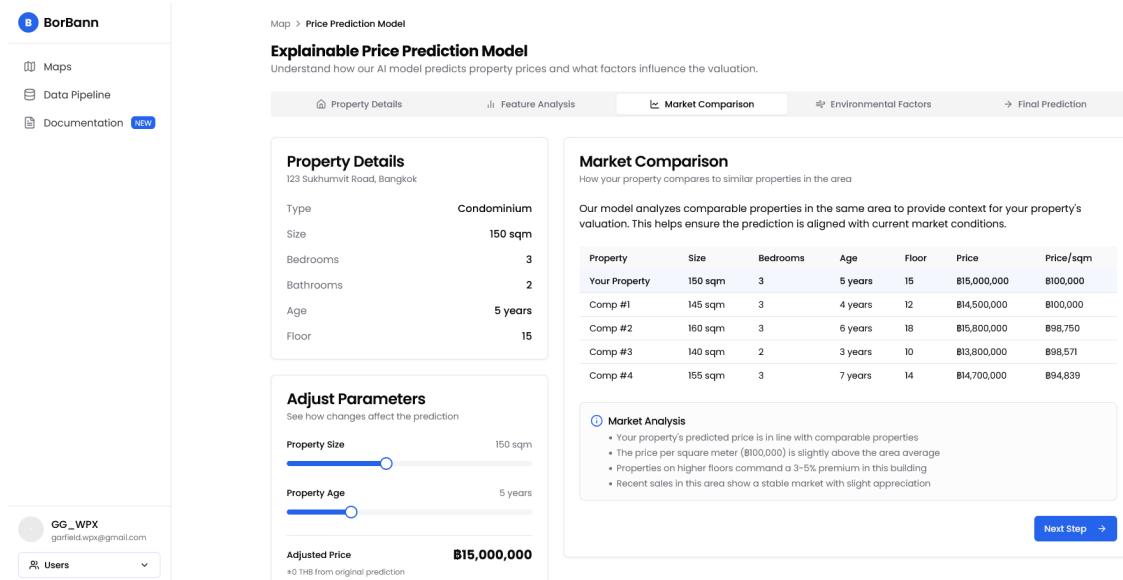


Figure 3.23: Explainable Price Prediction - Comparative Market Analysis

Figure 3.23 presents a comparison of the subject property against similar properties in the area. The table highlights key attributes and pricing metrics with supporting analysis of market positioning.

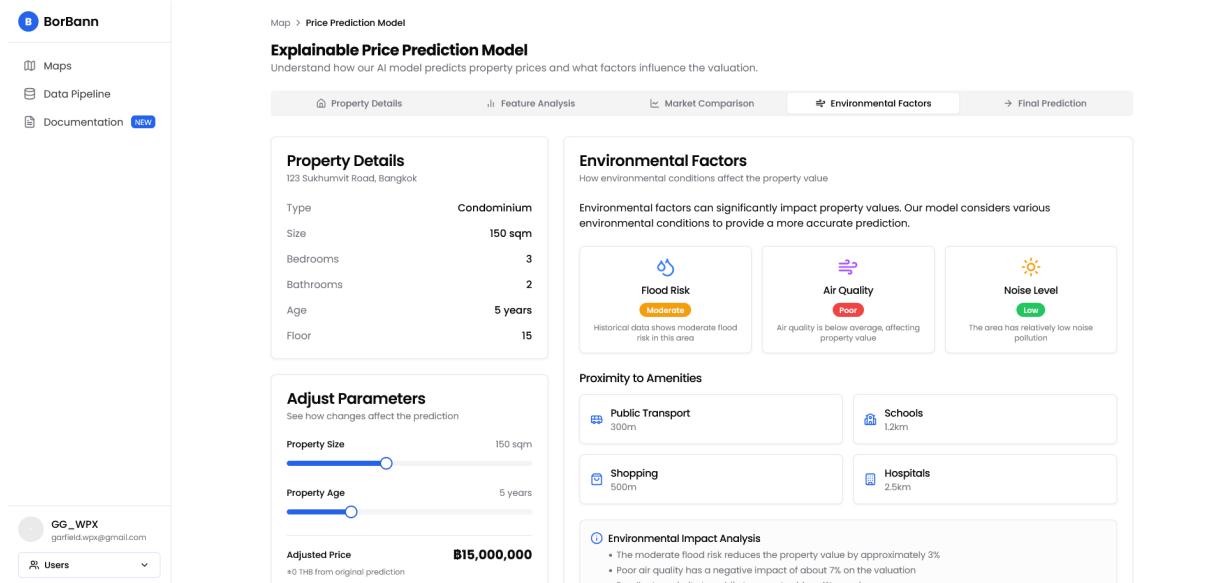


Figure 3.24: Explainable Price Prediction - Environmental Impact Analysis

Figure 3.24 analyzes environmental conditions and nearby amenities affecting property value. The interface displays flood risk, air quality, and proximity to key facilities with quantified impact on valuation.

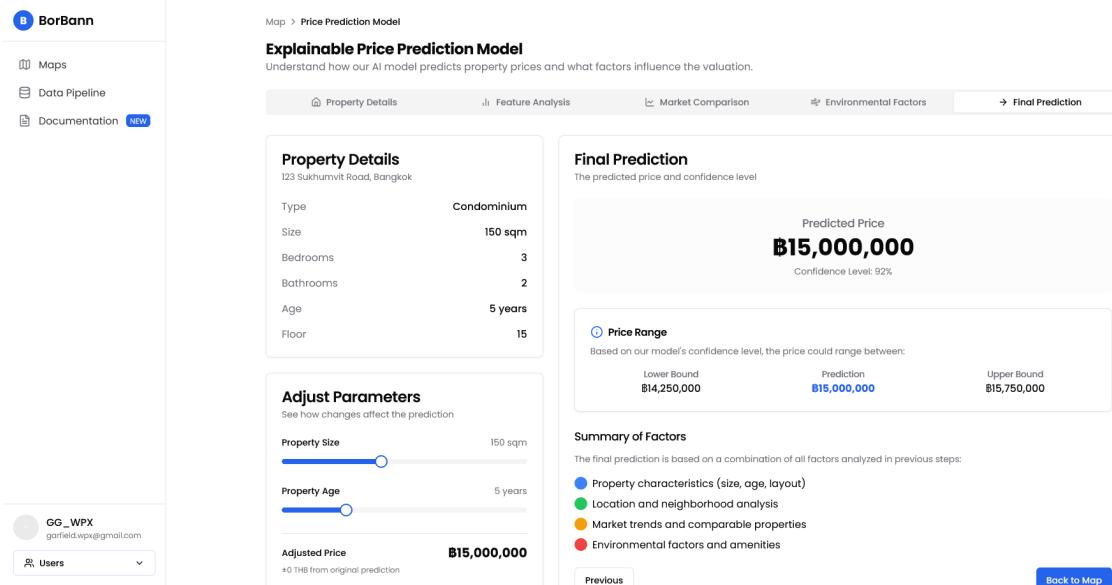


Figure 3.25: Explainable Price Prediction - Final Valuation with Confidence Range

Figure 3.25 shows the final price prediction with confidence metrics and range indicators. The summary section explains how the valuation synthesizes insights from all analytical components.

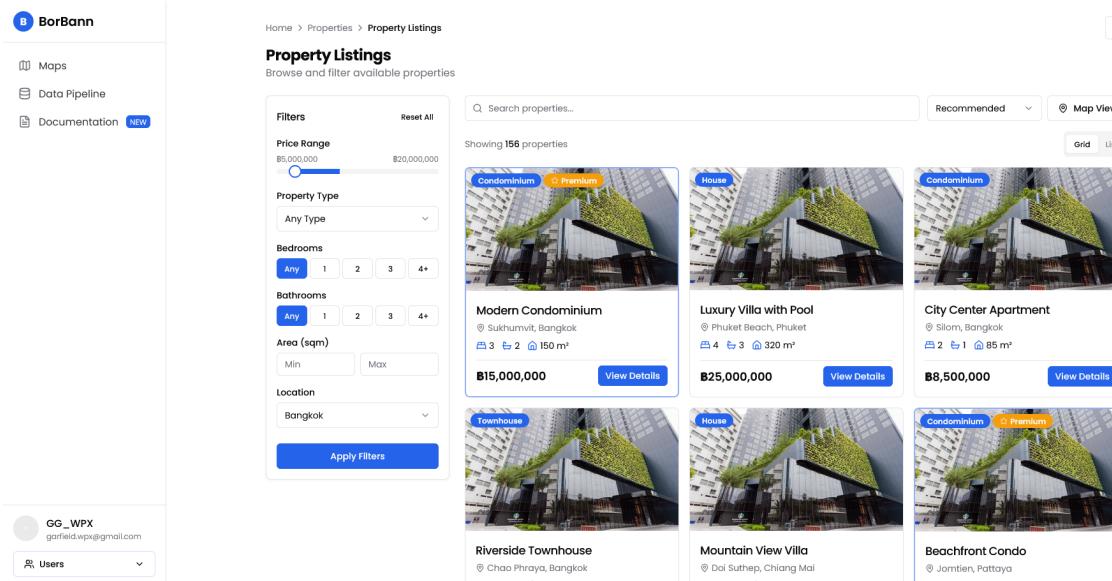


Figure 3.26: Property Listings Page

Figure 3.26 display property listings page with all listing that follow the filter tab the right.

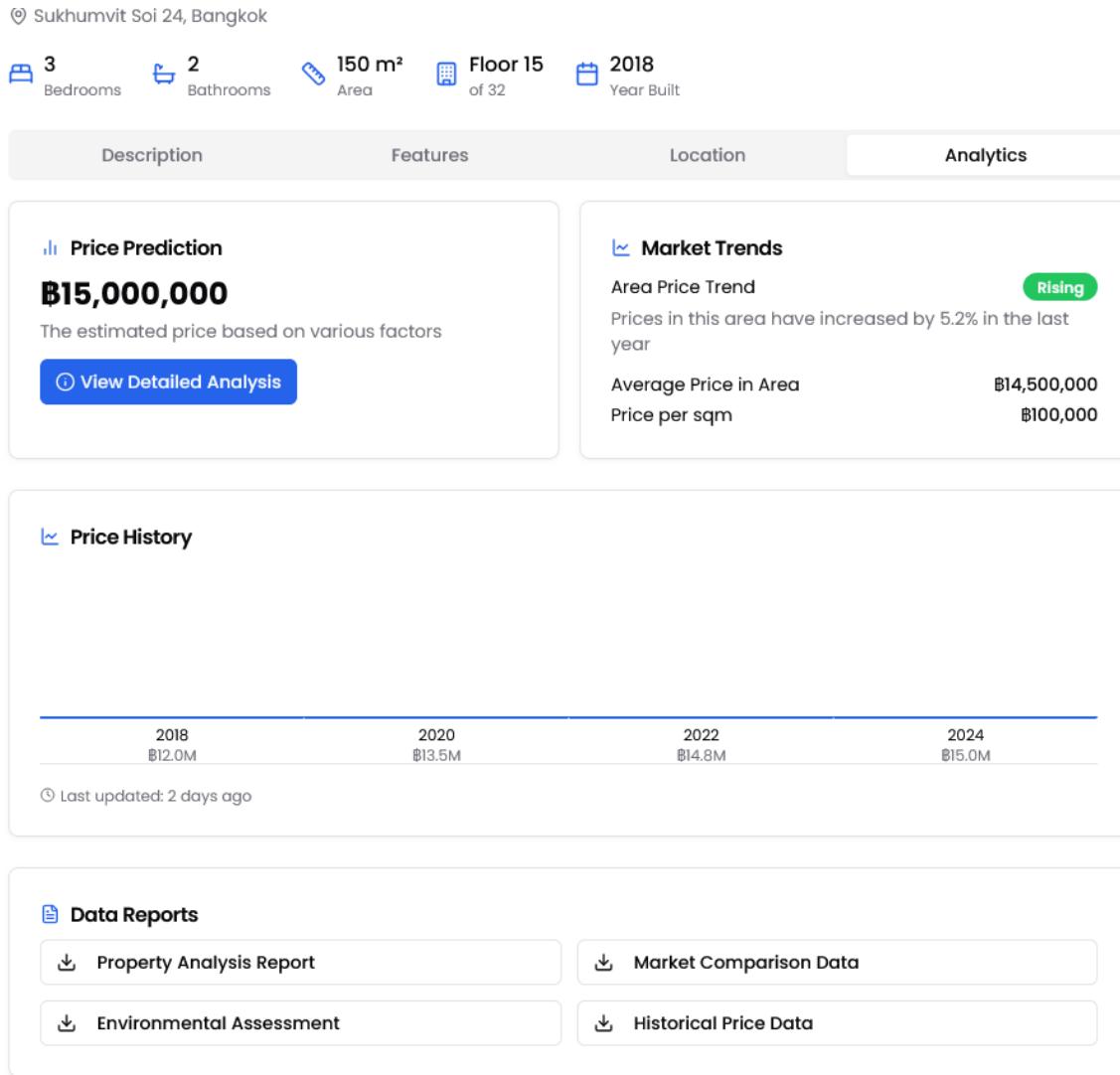


Figure 3.27: Property Listings Page - Analytic Tab

Figure 3.27 shows the analytic tab that show local context analytic of that specific listing.

# Chapter 4

## Software Architecture Design

### 4.1 Sequence Diagram

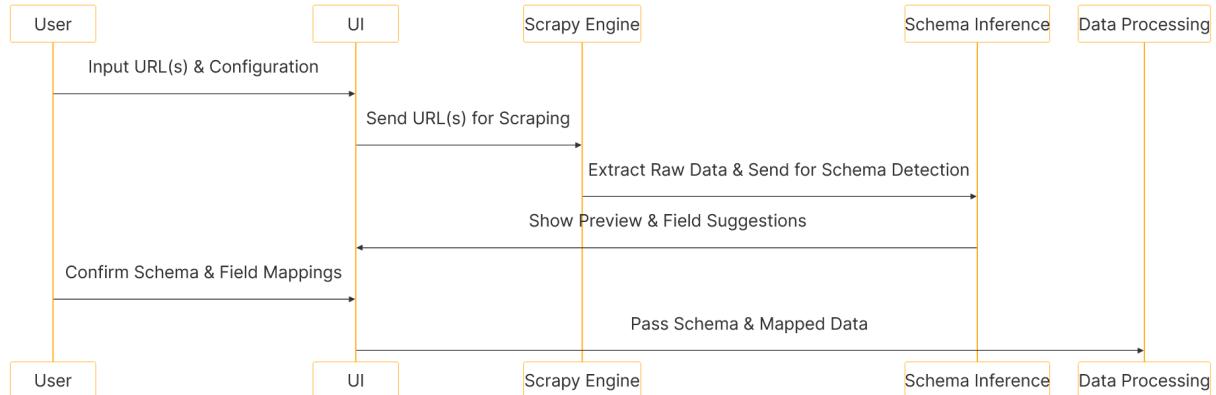


Figure 4.1: Sequence Diagram of Customizable Automated Data Integration Pipeline

The sequence diagram shows the flow of interactions between key components of the customizable automated data integration pipeline. The process begins with the **User**, who inputs URLs and configuration details via the **UI**. The **UI** sends the provided URLs to the **Scrapy Engine** for scraping.

Once the data is extracted, the **Scrapy Engine** forwards the raw data to the **Schema Inference** module for automatic schema detection. The **Schema Inference** module analyzes the data and returns a preview, along with field mapping suggestions, to the **UI**. The **User** then reviews the suggested schema and field mappings in the **UI**.

Upon confirmation by the **User**, the **UI** passes the finalized schema and mapped data to the **Data Processing** pipeline, where further processing and integration of the collected data occur.

## 4.2 AI Component

The BorBann platform has AI components that enhance its analytical capabilities and user experience. These components work together to provide build a real estate data platform adapt to the Thai market context. Each component integrate with each other to form a comprehensive analytics system:

- The Data Integration Pipeline feeds data to the Local Contextual Analytics system
- Local Contextual Analytics provides features to the Explainable Price Prediction Model
- The Retraining Model uses data from the pipeline to create customized predictions
- All components share a common data model that enables smooth information flow

### Explainable Price Prediction Model

The price prediction model delivers property price predictions with clear explanations of contributing factors.

#### Model Architecture

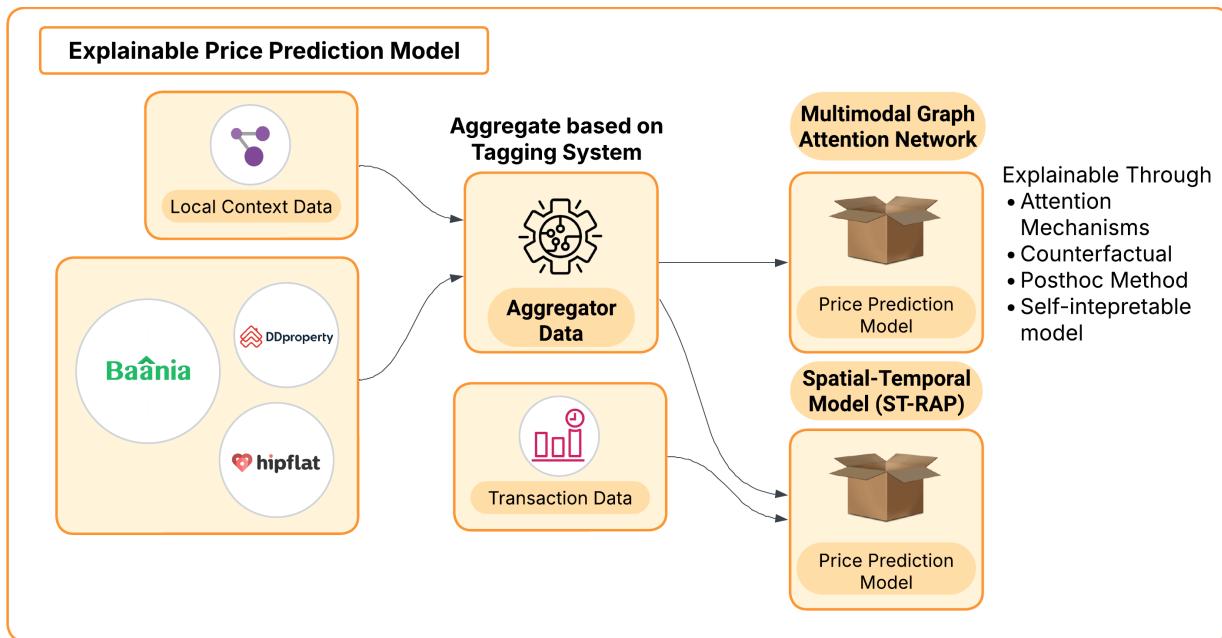


Figure 4.2: Explainable Price Prediction Data Flow

Figure 4.2 illustrates the architecture of the Explainable Price Prediction Model. The diagram shows how data flows from multiple sources (Baania, DDproperty, hipflat) and local context data into an Aggregator component that organizes information based on a tagging system. The aggregated data then feeds into two distinct prediction models:

a Multimodal Graph Attention Network and a Spatial-Temporal Model (ST-RAP). The explainability features are highlighted on the right, showing how the model provides transparency through attention mechanisms, counterfactual analysis, post-hoc methods, and self-interpretable modeling approaches.

- **Dual Modeling Approach:**

- *Tree-based Model:* With tree-based gradient boosting models (XGBoost[4]).
- *Multimodal Graph Attention Network:* With Multimodal Graph Attention Network[5] that is multi-modal model which can handle large graph.
- *Spatial-Temporal Model:* Using ST-RAP[6] for facilities-property graph input and time series of real estate pricing data

## Explainability Framework

- **In-model Attention:** With attention mechanism, we can look into weighted contributions of nodes, edges, or modalities
- **Post-hoc Explanation Module:** Uses KernelSHAP[7] (Algorithm to approximate SHapley Additive exPlanations) value calculation for feature attribution.
- **Self-Interpretable Components:** Extracts rules from complex models and implements decision tree surrogate models that approximate complex model behavior

## User Interface Components

- **Interactive Visualizations:** Feature importance charts, and price trend projections with confidence intervals
- **Explanation Generation:** Natural language generation of price explanations and highlighting of key value drivers

## Local Contextual Analytics

This component analyzes environmental conditions and proximity factors to evaluate property context and risk:

### Model Architecture

Figure 4.3 depicts the Local Contextual Analytics system. The diagram shows various data sources including GISTDA, Bangkok Metropolitan Administration, news outlets, and property listing platforms (Baania, hipflat) feeding into an Aggregator Service. This service collects different types of data through web scraping, API fetching, and dataset downloads. The collected data undergoes preprocessing with outlier detection, value imputation, and feature engineering before being stored in specialized databases (Vector, Time-Series,

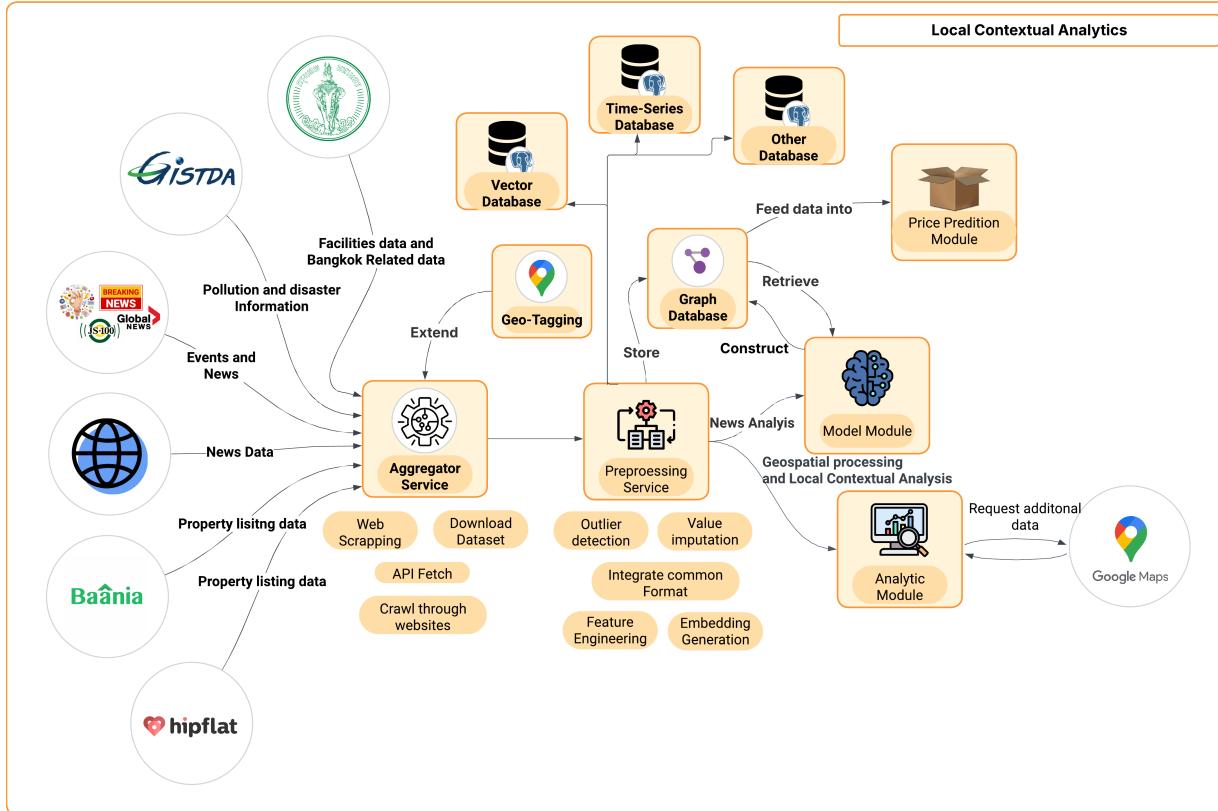


Figure 4.3: Local Contextual Analytic Data Flow

Graph). The Model Module and Analytic Module process this information to provide geospatial analysis and local contextual insights that ultimately feed into the Price Prediction Module.

- **Graph Database:** Stores heterogeneous data in Neo4J or other knowledge graph database
- **Vector Database:** Stores embedding from preprocessing unit within PostGreSQL with pgvector that will provide vector database capabilities
- **Timeseries Database:** Stores time-series data within Timescale
- **Relational Database:** Stores relational data in PostgreSQL
- **NoSQL Database:** Stores unstructured data within MongoDB
- **Model Module:**
  - Heterogeneous Graph Construction using k-NN or GCN
  - GCN models for spatial relationships
  - NLP models for news analysis
- **Price Prediction Module:** Integrated model consuming all processed features

## Analytics Capabilities

- **Climate and Environmental Analysis:** Evaluates climate risk, pollution levels, and disaster assessment
- **Proximity Analysis:** Evaluates nearby locations and facilities, analyzing relationships between facilities
- **News Integration:** Incorporates local news into property assessment

## Customizable Automated Data Integration Pipeline

This pipeline enables non-technical users to connect any data source into a unified system:

### LLM Module

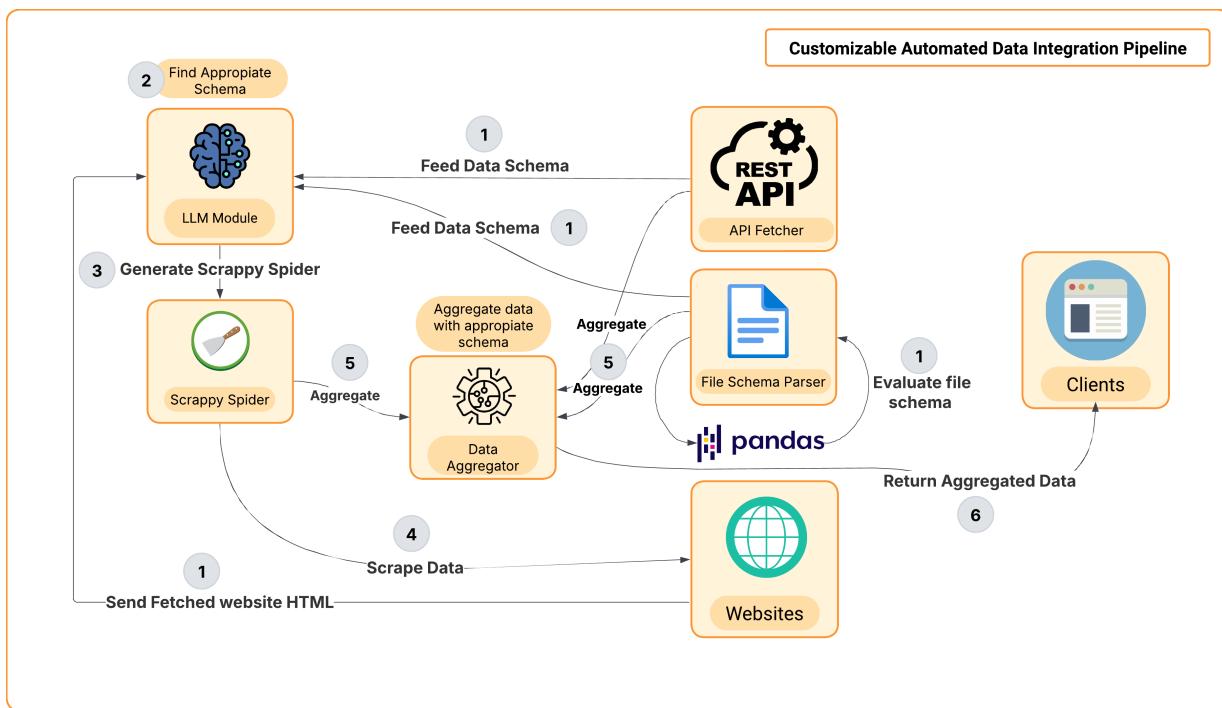


Figure 4.4: Customizable Automated Data Pipeline Data Flow

Figure 4.4 presents the Customizable Automated Data Integration Pipeline. The workflow begins with data sources (API Fetcher, File Schema Parser, Websites) being evaluated. An LLM Module analyzes these sources to find appropriate schemas (step 2), then generates Scrappy spiders for web scraping (step 3). The spiders extract data from websites (step 4), while the Data Aggregator combines information from all sources (step 5). Finally, the aggregated data is returned to clients (step 6). This pipeline enables non-technical users to integrate diverse data sources through an automated, LLM process.

- Analyzes data sources to find appropriate schemas

- For websites, generates Scrappy spider configurations automatically
- Bridges the gap between unstructured and structured data

## Data Processing

- **Scrappy Spider:** Dynamically generated web scrapers based on LLM analysis that extract targeted data from websites according to the determined schema
- **Data Aggregator:** Central component that combines data from all sources, harmonizes different schemas into a unified structure, and uses appropriate schema mapping determined by the LLM

## Retraining Model with Pipeline Data

This component allows users to create custom prediction models by combining their pipeline data with platform data:

### Technical Implementation

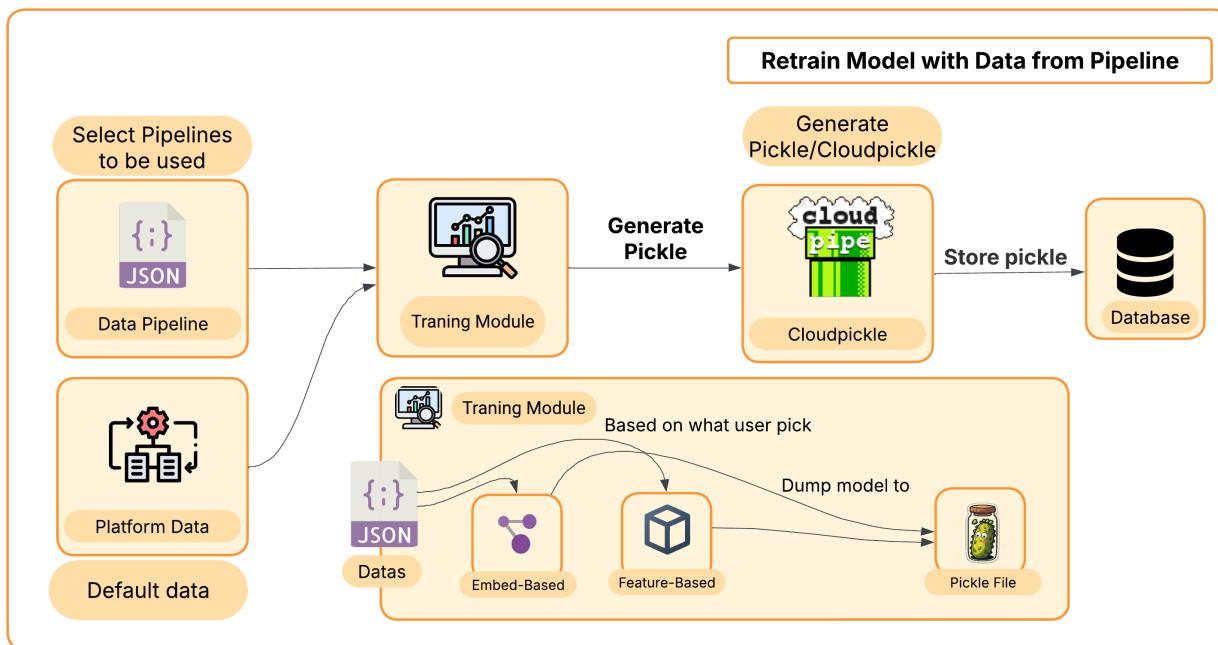


Figure 4.5: Retrain Model with Data from Pipeline Data Flow

Figure 4.5 shows the Model Retraining Pipeline. The diagram illustrates how users can select pipelines and combine them with platform data to train custom models. The Training Module processes this data and allows users to choose between embed-based or feature-based modeling approaches. The system generates pickle/cloudpickle files of the trained models, which are then stored in a database for future use. This component empowers users to create specialized prediction models tailored to their specific data and requirements.

- **Training Engine:** Implements automated training engine that rely on embedding-based models to avoid problem with unmatch input feature and tree-based models (for structured data), and builds parameter tuning system using random search if user doesn't specify ones.
- **Model Serialization:** Creates versioned model files for persistence and stores serialized models in pickle format in database with metadata
- **Deployment Framework:** Provides APIs for model inference, enables batch prediction, and implements monitoring for model drift detection

# Chapter 5

## AI Component Design

This chapter describes how Artificial Intelligence (AI) components are designed and integrated into the overall system. Each section starts with a clear objective and provides guidance on analysis, design, implementation, and evaluation of AI modules.

### 5.1 Business Context and AI Integration

Figure 5.1 shows the overview of the system workflow and how each component works together. It illustrates that AI will be used in four components: Data Integration Pipeline, Explainable Price Prediction, Property and Neighborhood Insight, and Pricing Explanation.

For each component, I will explain why using AI is both feasible and necessary.

#### 1. Data Integration Pipeline

Using AI is suitable in this case because content on websites varies by type of information and other elements, so AI needs to be implemented to help parse and understand the context and extract information.

When aggregating multiple data sources, differences in data schemas present a significant challenge. We need to establish a centralized data schema, and AI can help users accomplish this more easily by suggesting related fields.

For web scraping, the problem is complex and constantly changing because website structures vary across multiple sites and are difficult to parse with fixed rules. For file and API sources, the challenge is less complex since we can extract data from files and fetch data from API endpoints directly. However, complexity increases when combining these sources into one unified pipeline.

We can accept some incompleteness in this module. Missing fields in the aggregated data will not significantly affect the analysis when working with large volumes of data.

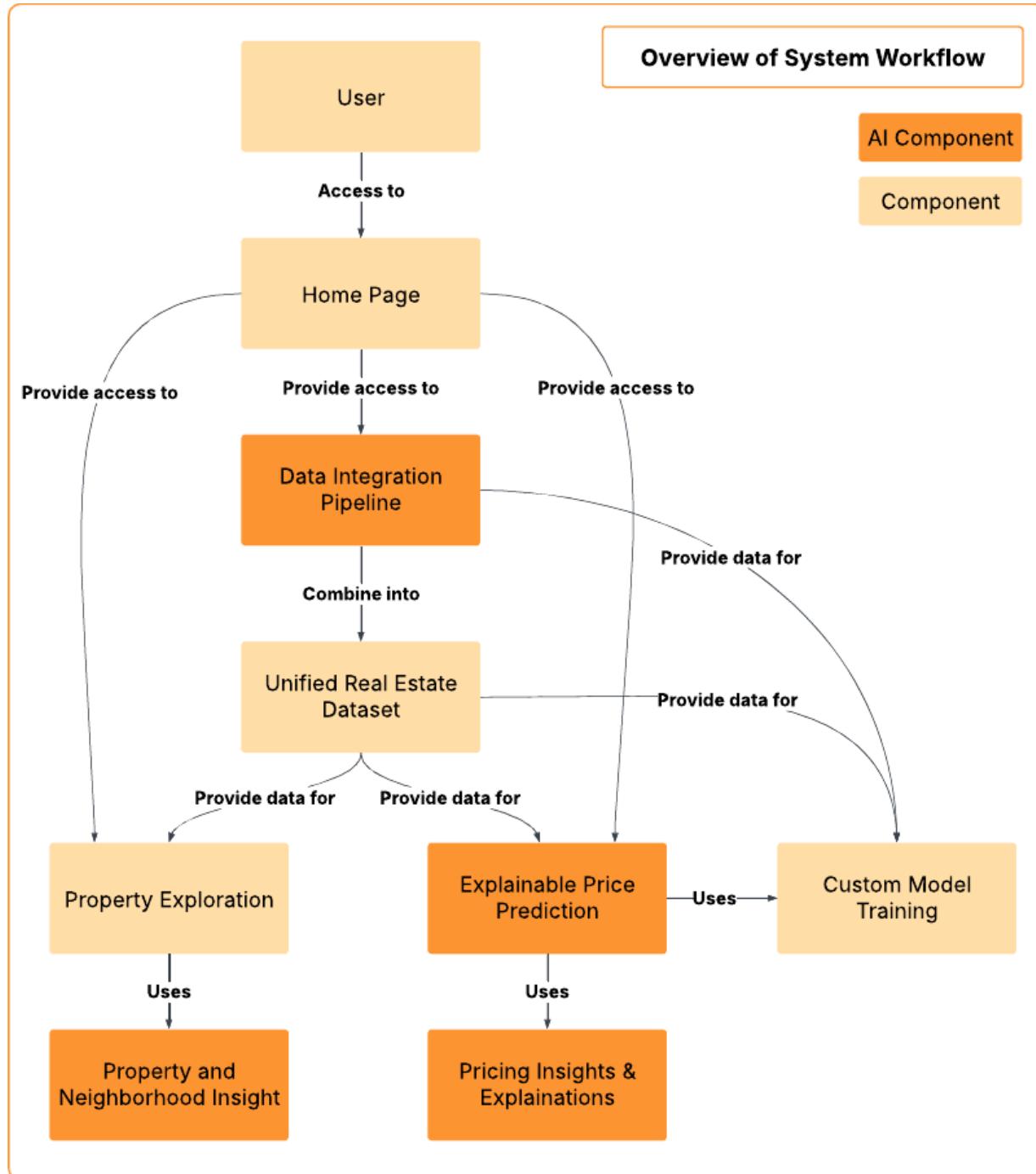


Figure 5.1: Overview system workflow

## 2. Explainable Price Prediction

AI is appropriate for price prediction because housing prices are influenced by numerous factors that interact in complex, non-linear ways. Traditional rule-based systems cannot effectively capture these intricate relationships.

The housing market constantly evolves with changing economic conditions, buyer preferences, and seasonal variations. AI models can adapt to these shifts by identifying new patterns in the data that might not be obvious to human analysts.

We can accept predictions that are not 100% accurate since real estate valuation inherently involves some uncertainty. However, by using explainable AI approaches, we can provide confidence intervals and explain the key factors influencing each prediction, making the system valuable even with some margin of error.

## 3. Property and Neighborhood Insight

AI is well-suited for generating property and neighborhood insights because this requires analyzing diverse data types including text descriptions, images, geographic information, and numerical data. The relationships between these varied data sources are complex and difficult to codify with traditional rules.

The characteristics that make a neighborhood desirable change over time and vary across different buyer segments. AI can identify emerging trends and personalized insights that static analysis would miss.

Perfect completeness is not essential, as providing valuable insights on the most significant factors affecting property desirability is more important than capturing every minor detail. Users benefit from focused, relevant information rather than exhaustive analysis.

## 4. Pricing Explanation

Using AI for pricing explanation is appropriate because explaining property valuations involves communicating complex relationships between numerous factors in an accessible way. These explanations need to adapt to each property's unique characteristics and the specific market context.

The relative importance of different pricing factors changes across markets and over time. AI can generate contextual explanations that reflect these dynamics rather than relying on fixed templates.

While we can accept explanations that might not cover every possible factor influencing price, the system provides significant value by highlighting the most important considerations and presenting them in a clear, understandable format for users.

## 5.2 Goal Hierarchy

This section outlines the hierarchical structure of goals for our real estate valuation system, beginning with organizational objectives and flowing down to specific AI model goals. For each level, we provide clear metrics to measure success.

### Organizational Goals

The primary organizational goals for this AI system are:

- To establish a trusted platform for accurate and transparent real estate valuations
- To build a reputation for innovation in applying AI to real estate challenges

Success at the organizational level will be measured through:

- Recognition through awards

### System Goals

At the system level, our goals are:

- To integrate diverse real estate data sources into a unified, high-quality dataset
- To generate accurate property valuations with clear explanations for price factors
- To provide insightful property and neighborhood analysis to inform decision-making
- To deliver a reliable, responsive user experience across different devices and user types

System success metrics include:

- System uptime and response time statistics
- Data completeness and quality indicators across different property types and regions
- System error rates and exception handling effectiveness
- System scalability under increasing data volumes and user numbers

## User Goals

For our users, the goals are:

- To receive insightful property valuations they can trust for decision-making
- To understand the key factors influencing property prices in specific markets
- To gain insights about properties and neighborhoods beyond basic statistics
- To save time in researching and analyzing real estate opportunities

User success metrics will be assessed through:

- User satisfaction surveys and net promoter scores

## AI Model Goals

At the most specific level, our AI model goals are:

- To accurately predict property prices with clearly quantified confidence levels
- To identify and weigh the most influential factors affecting property values
- To provide explanations for predictions that are both technically sound and accessible to non-technical users

AI model performance will be measured through:

- Statistical accuracy metrics including mean absolute error, root mean squared error, and R-squared value compared to actual transaction prices
- Explanation quality assessed through user comprehension testing
- Comparative performance against benchmark models and traditional valuation methods
- Drift detection metrics to identify when model retraining is necessary
- Computational efficiency metrics including inference time and resource utilization

## 5.3 Task Requirements Analysis Using AI Canvas

This section presents a detailed analysis of our AI system's task requirements using the AI Canvas methodology. This approach helps us clearly articulate what each AI component should accomplish, how it will operate technically, and the conditions under which it will function.

## AI Task Requirements

For each AI component in our system, we analyze three key dimensions:

- **Requirements (REQ):** The specific objectives and functions each AI component must fulfill
- **Specifications (SPEC):** The technical approach and methods the AI will employ
- **Environment (ENV):** The operational conditions, constraints, and context in which the AI will function

### 1. Data Integration Pipeline

**Requirements (REQ):** The AI component must extract structured data from diverse sources including property listing websites, government databases, and unstructured documents. It needs to identify property characteristics, pricing information, location data, and temporal attributes across varying formats. The system must normalize extracted data into a unified schema.

**Specifications (SPEC):** This component will implement a hybrid approach combining rule-based extraction for standardized sources and deep learning models for unstructured content. Named entity recognition models will identify property attributes within text, while transformer-based architectures will handle context-dependent extraction tasks.

**Environment (ENV):** The component will operate in a data environment characterized by high heterogeneity across sources, frequent changes in website structures, and varying data quality. It must process large volumes of daily updates while maintaining extraction accuracy. The system requires periodic retraining as new data sources are integrated and reasonable human oversight for exception handling of complex cases that fall outside standard patterns.

### 2. Explainable Price Prediction

**Requirements (REQ):** This AI component must generate accurate property valuation estimates with quantified confidence intervals. It needs to identify key value drivers specific to each property, adapt to regional market dynamics, and provide predictions that remain reliable even with incomplete input data. The system must detect when it lacks sufficient information for reliable prediction and communicate these limitations transparently.

**Specifications (SPEC):** The prediction engine will utilize an ensemble approach combining gradient-boosted decision trees for tabular data with graph neural networks to capture neighborhood relationships and spatial dependencies. SHAP values and counterfactual explanations will provide feature importance analysis.

**Environment (ENV):** This component operates within a complex market environment.

### 3. Property and Neighborhood Insight

**Requirements (REQ):** The AI must analyze multilayered neighborhood data to identify significant patterns and trends relevant to property valuation. It needs to generate insights about local amenities, infrastructure developments, community characteristics, and future growth potential.

**Specifications (SPEC):** This component will utilize multimodal analysis techniques combining geospatial machine learning for location-based features with natural language processing for textual descriptions and sentiment analysis. The system will implement clustering algorithms to identify comparable neighborhoods and temporal modeling to detect emerging trends.

**Environment (ENV):** The insight generation occurs in an information-rich but fragmented environment with data spanning multiple domains including transportation, education, commerce, and safety. The component must operate with varying data availability across neighborhoods and maintain cultural sensitivity when analyzing community characteristics. It needs to distinguish between transient and persistent neighborhood attributes while balancing detail with relevance in its output.

### 4. Pricing Explanation

**Requirements (REQ):** This component must translate complex valuation models into clear, intuitive explanations. It needs to communicate uncertainty appropriately, highlight the most influential factors affecting a specific property's value, and provide comparative analysis with similar properties. The system should generate explanations that help users understand market dynamics without overwhelming them with technical details.

**Specifications (SPEC):** The explanation system will implement a natural language generation pipeline built on a large language model fine-tuned for real estate domain knowledge. It will incorporate techniques from the field of explainable AI including feature attribution visualization, importance ranking. The system will use templates for consistent structure while leveraging dynamic content generation for property-specific insights.

**Environment (ENV):** This component operates at the interface between technical prediction systems and non-technical users.

## AI Canvas Development

Figure 5.2 presents an AI Canvas diagram for an Explainable Price Prediction & Context-Aware Analytics system tailored to the Thai real estate market. This strategic planning tool articulates how artificial intelligence creates value through structured components that guide implementation.

The AI Canvas comprises eight interconnected sections that collectively define the system's purpose and operation. The Prediction section establishes the core functionality: estimating property market values based on input features, providing confidence intervals to quantify uncertainty, and delivering accessible explanations to users. This works in concert with the Judgment section, which articulates the critical trade-offs the system must evaluate, focusing on assessing prediction reliability through model confidence metrics, data completeness evaluation, and deviation analysis from comparable properties.

The Action section defines how the system's outputs are translated into tangible steps, displaying valuation results with confidence levels, highlighting the top contributing features to predicted values, and explaining results through user-friendly descriptions. These actions lead to the Outcome section, which clarifies the ultimate value proposition: enabling users to make informed real estate decisions across pricing, investing, and negotiations, while simultaneously collecting usage statistics for ongoing system optimization.

The Input Data section catalogues the available information sources: property features including location, size, type, age, and amenities; environmental data encompassing infrastructure, flood zones, and news; and market data covering recent sales and current listings. Complementing this, the Training Data section defines the labeled examples powering the model: historical sales and rental prices that have undergone cleaning, normalization, and imputation processes to handle data quality issues.

The Feedback section outlines how the model will learn over time by tracking metrics like average deviation between predictions and actual selling prices. The Intervention section establishes boundaries for human oversight, calling for expert involvement when predictions show low confidence or high deviation, while implementing fallback mechanisms when prediction certainty falls below acceptable thresholds. The Explanation section details the technical approaches for transparency: SHAP or LIME-based visual feature attribution combined with Large Language Models to generate intuitive explanations.

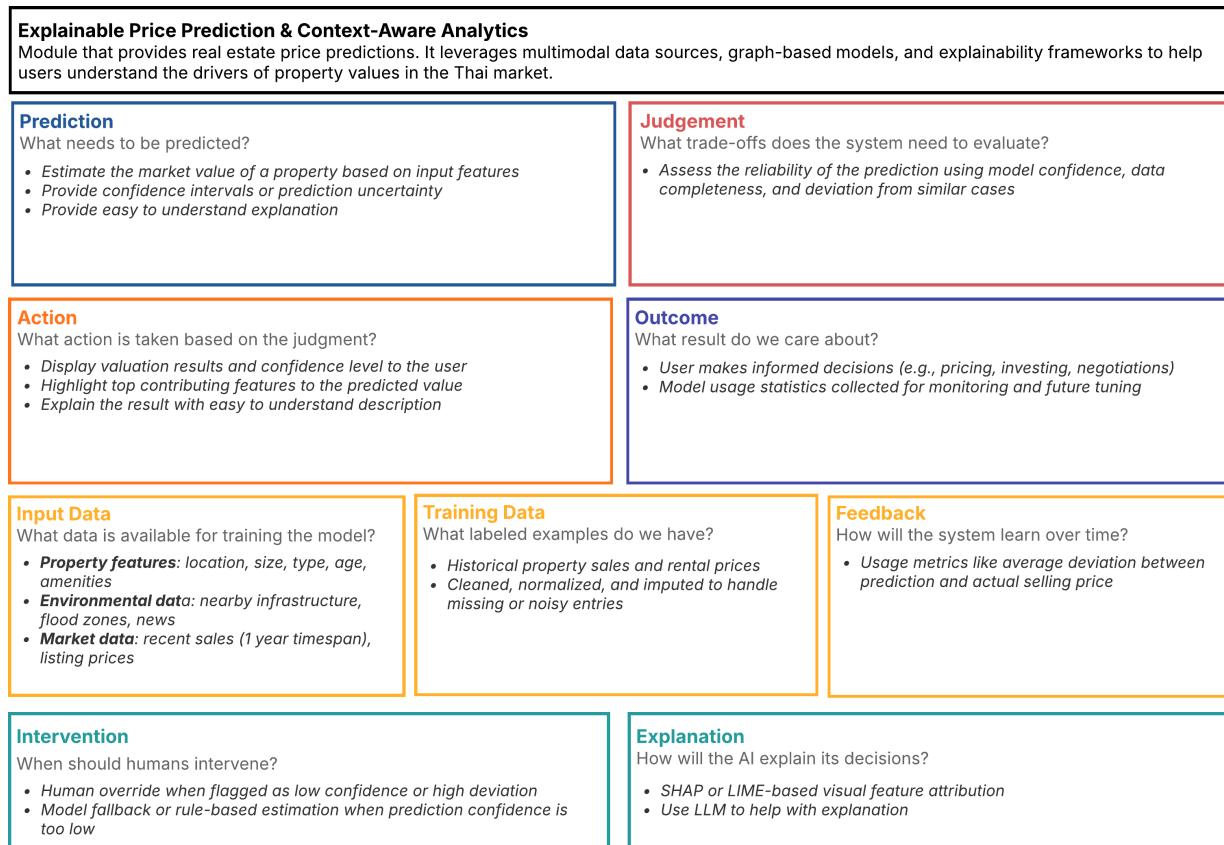


Figure 5.2: Overview system workflow

## 5.4 User Experience Design with AI

This section explains how AI is used to improve the user experience in our real estate system. AI is not just a background tool—it helps users by doing tasks, adding helpful info, giving smart suggestions, and adjusting to user needs. These features are built into key parts of the system, like data handling, neighborhood analysis, and price prediction. The design focuses on being clear, easy to use, and useful for different types of users.

### Automated Pipelines

The pipeline system in BorBann is not just a backend tool. It's a dynamic, AI interface that enables even non-technical users to build, manage, and leverage data workflows for training personalized real estate models.

The system is designed using an **Automate** style that automatically handles repetitive technical tasks—like schema inference and spider generation—but still gives users the power to manually adjust the process.

#### 1. Pipeline Creation and Management

Users start by selecting data sources—like websites, files, or APIs—and use a no-code interface to configure their pipeline. The system generates scraping rules using an LLM and recommends schema alignments automatically.

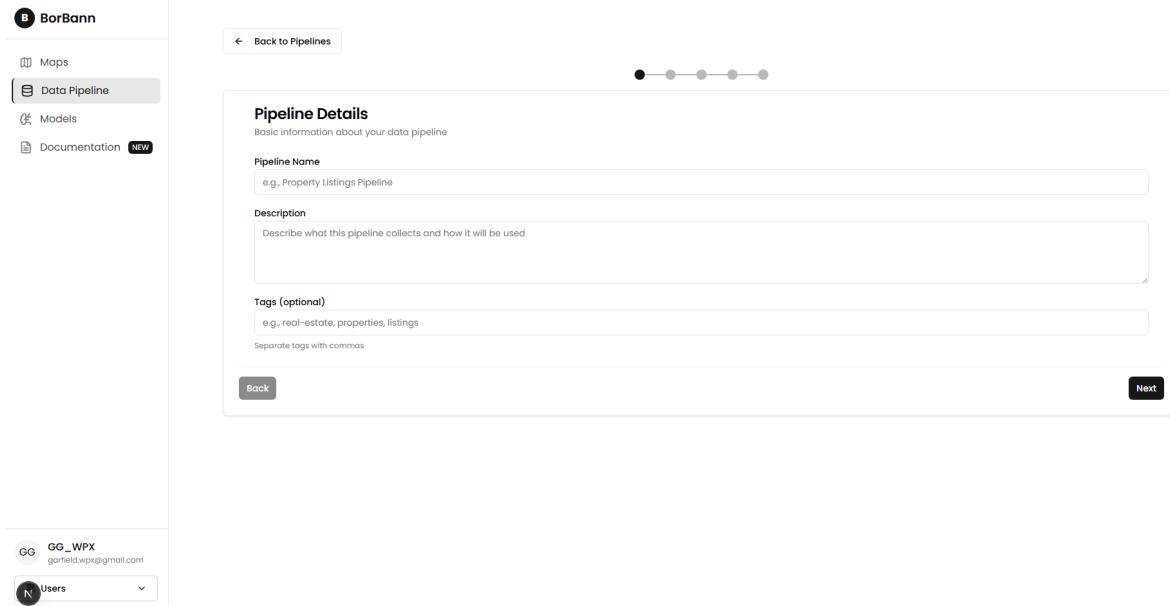


Figure 5.3: Pipeline Creation Interface

Figures 5.3 and 5.4 show how users input data source URLs and set extraction options with help from the AI.

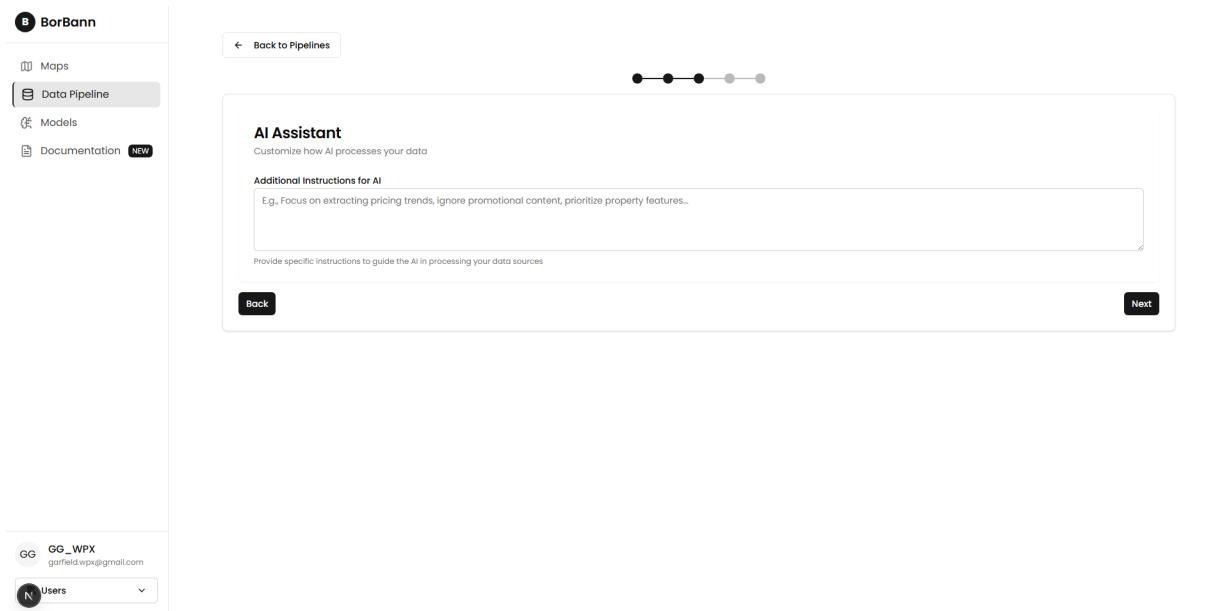


Figure 5.4: Pipeline Creation Interface – Additional Prompt

## 2. Field Customization and Schema Annotation

After setting up the source, users can view, modify, or remove fields detected by the system. The interface visually maps fields across sources, includes data type validation, and supports custom field creation via formulas.

| ID   | Title            | Price       | Bedrooms | Bathrooms | Location    | Sq. Ft. |
|------|------------------|-------------|----------|-----------|-------------|---------|
| P001 | Modern Apartment | \$350,000   | 2        | 2         | Downtown    | 1,200   |
| P002 | Luxury Villa     | \$1,250,000 | 5        | 4         | Suburbs     | 3,500   |
| P003 | Cozy Studio      | \$180,000   | 1        | 1         | City Center | 650     |

Figure 5.5: Field Management Interface

Figure 5.5 shows the functionalities to customize the schema and data source integration.

### 3. Pipeline Monitoring and Status Overview

Users can view a dashboard that summarizes the status of each pipeline—categorized as Active, Paused, or Failed, or Completed. Each pipeline card is annotated with insights.

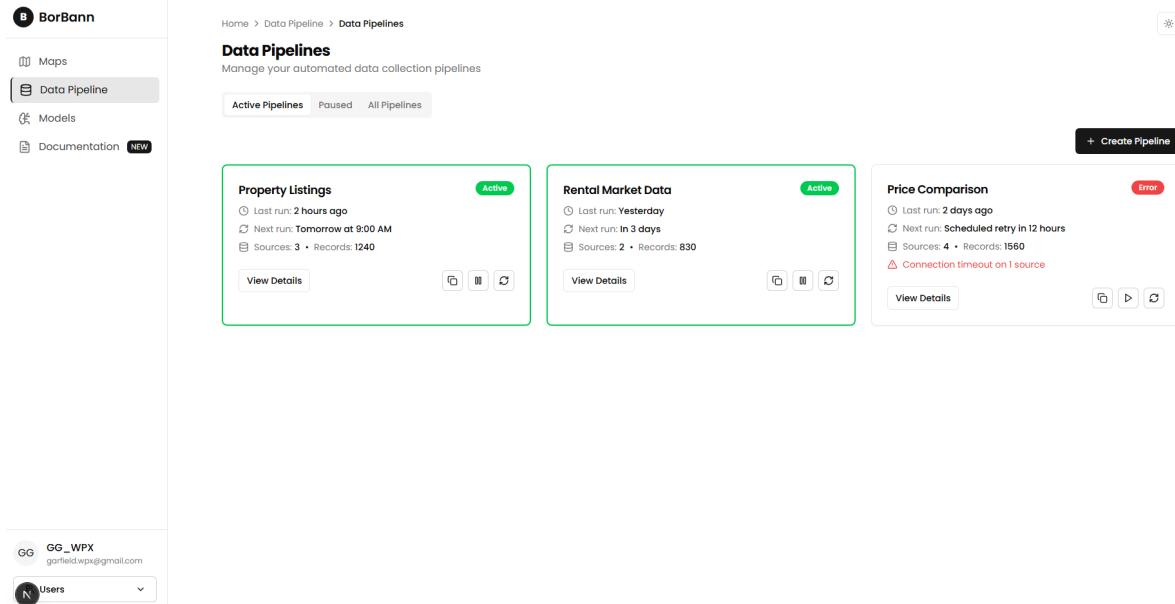


Figure 5.6: Pipeline Dashboard Interface

Figure 5.6 shows how the interface represents pipeline statuses; successful pipelines are highlighted with green-bordered cards.

## Neighborhood Insight

The Neighborhood Insight feature uses various APIs and tools to analyze environmental conditions, nearby facilities, local amenities, and even news sentiment. The goal is to support smarter decisions by making the neighborhood story as transparent and rich as the property details.

This feature uses **Annotate**, which overlays real-time and historical context—like flood risk, school quality, and air pollution levels—into property views; and **Automate**, where the agent automatically pulls data from multiple sources and updates insights with minimal input.

### 1. Local Context Analytics Interface

When users view a property, the system automatically presents key neighborhood metrics, including:

- Flood risk history and air quality trends
- Distance and quality scores for nearby schools, hospitals, and transit points

- Local news sentiment

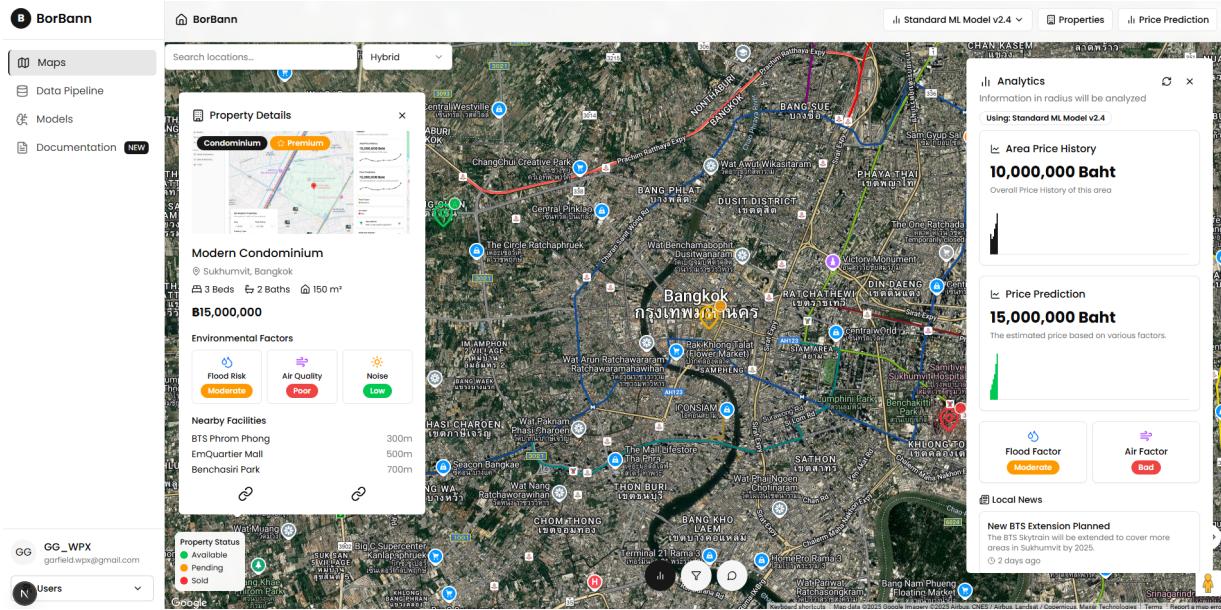


Figure 5.7: Environmental Impact Analysis

Figure 5.7 shows the analytics interface consisting of environmental data, pricing, and property-specific details along with nearby facilities.

## Explainable Price Prediction

This feature blends predictive modeling with real-time visualizations and natural language explanations. Unlike typical black-box systems, BorBann’s model lets users interact with the logic behind the number. Users can explore, adjust, and challenge the AI’s assumptions.

The user experience combines:

- **Annotate** – each prediction includes visual and textual breakdowns of contributing factors.
- **Prompt** – the system suggests related factors for simulating “what-if” scenarios.
- **Automate** – the system recalibrates predictions as more data is integrated.

### 1. Prediction Overview

When a user selects a property, the system immediately displays:

- Predicted price range (upper and lower bounds)
- Confidence interval

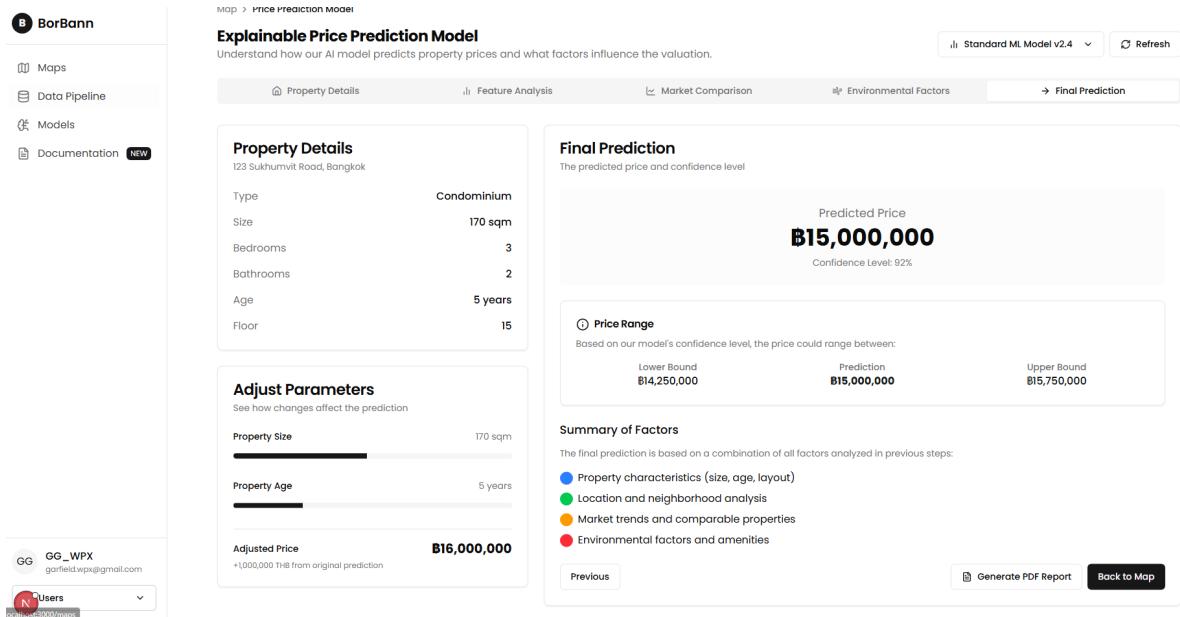


Figure 5.8: Prediction Overview Interface

- Base prediction with timestamp of latest data sync

Figure 5.8 shows the price range, confidence bands, and a clean summary layout.

## 2. Feature Contribution Analysis

The system explains which factors influenced the prediction most — such as location, property size, developer reputation, and local context.

Figure 5.9 shows an interface that visualizes the impact of each factor using bar graphs and percentage values.

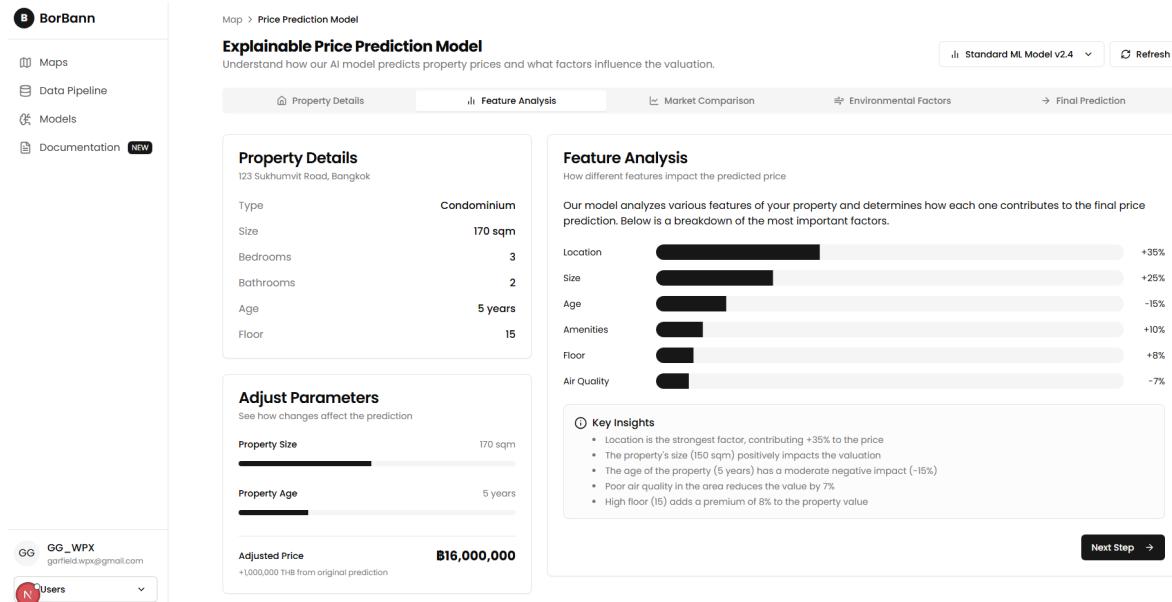


Figure 5.9: Feature Contribution Analysis Interface

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