C++ Programming

Waste Management System using C++ with Multi-Route Optimization Algorithms (Screenshots)

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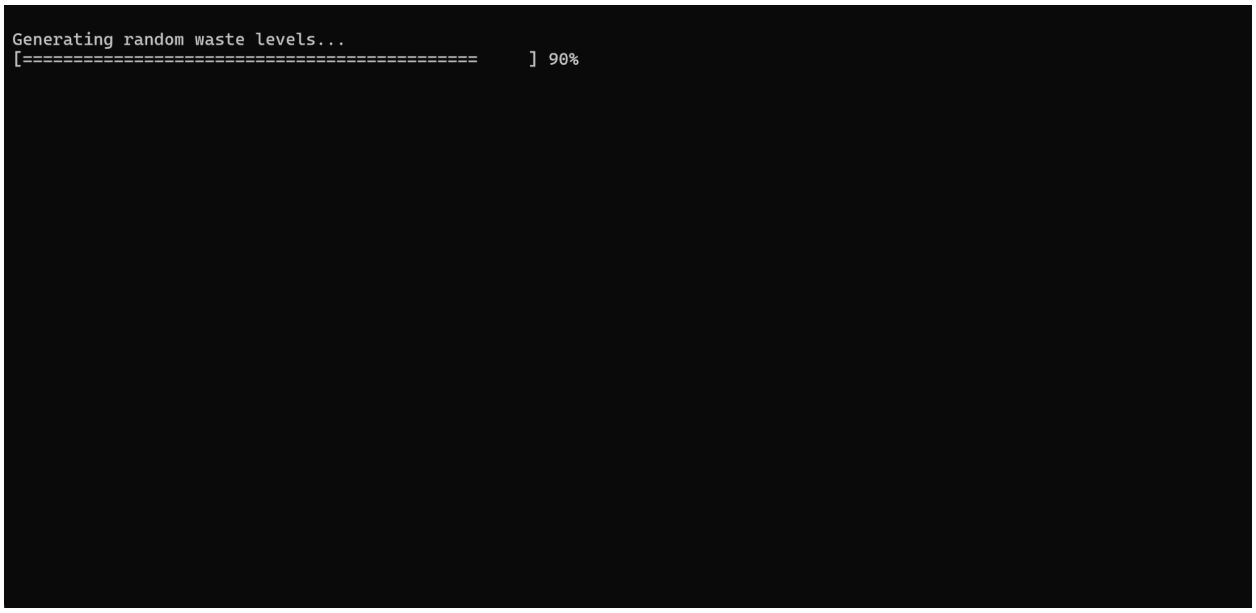
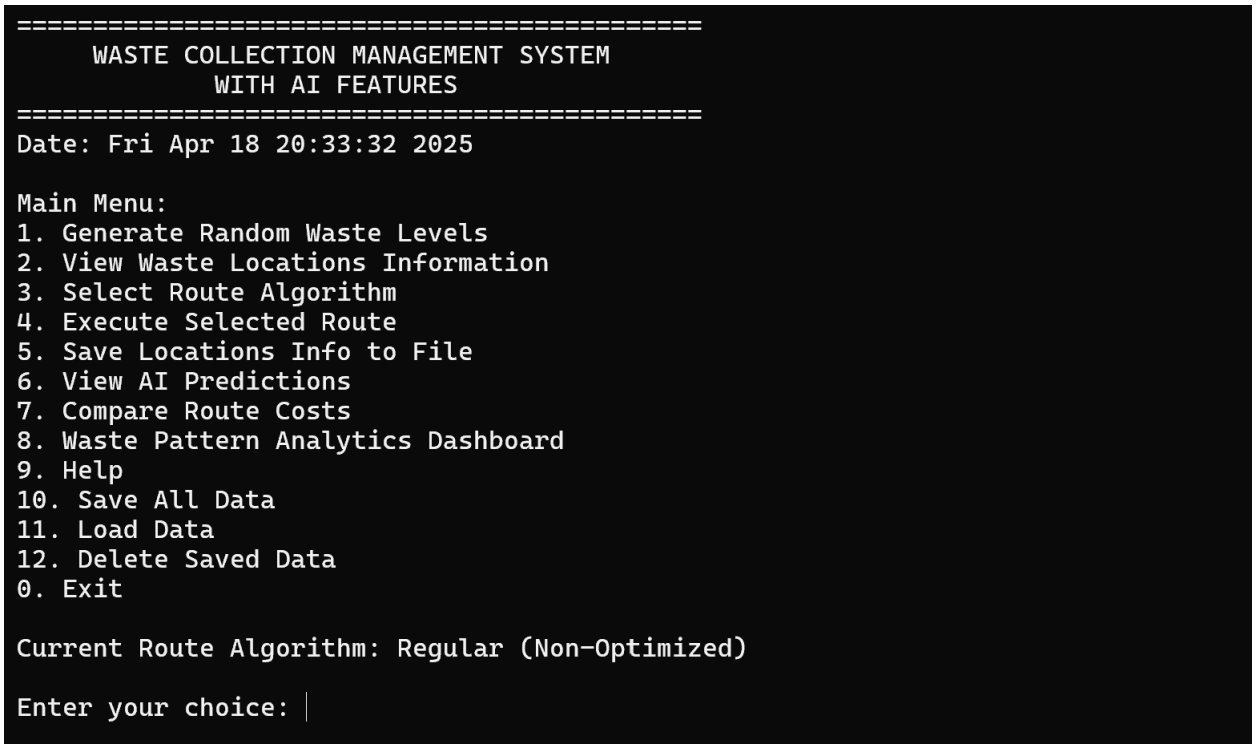
1. System Initialization in Progress



Description: This screenshot highlights the startup phase of the Waste Management project. It features a dynamic loading screen, where random waste levels are being generated. The progress bar, shown at 90% completion, indicates the near readiness of the system, setting the stage for the program’s functionality.

2. Welcome to the Main Menu: Your Command Center



Description: This screenshot showcases the centralized hub of your Waste Management project. With a user-friendly menu spanning key operations—from viewing waste locations to advanced analytics—the interface empowers users to manage waste efficiently. The highlighted "Regular (Non-Optimized)" route algorithm points to a standard setup, awaiting customization and optimization for enhanced performance.

3(a) Generating Random Waste Levels: Setting the Stage for Analysis

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
              WITH AI FEATURES
==========================================
Date: Fri Apr 18 20:33:32 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 1
```

Description: This screenshot captures the moment when the user selects option 1, "Generate Random Waste Levels," from the main menu. The system initiates the process of creating simulated waste data, providing a foundation for further exploration, such as optimizing routes or analyzing waste patterns. This step underscores the project's dynamic capability to adapt to different data scenarios

3(b) Waste Levels Successfully Generated: System at Work

```
Generating random waste levels...
[==================================================] 100%

============================================
Generating Random Waste Levels
============================================
Location                Previous %     New %
--------------------------------------------
Kuala Lumpur Central    63             39
Petaling Jaya           47             53
Shah Alam               0              99
Subang Jaya             87             15
Ampang                  25             18
Klang                   60             6
Cheras                  42             95
Puchong                 83             62
Putrajaya               59             74
Cyberjaya               21             69
============================================

SUCCESS: Waste levels generated successfully!

Random waste levels generated.
Press any key to continue . . .
```

Description: After the user selects option 1, the system completes the process of generating random waste levels across various locations. The table clearly displays the previous and newly generated waste percentages for areas like Kuala Lumpur Central, Petaling Jaya, and more. This step demonstrates the system's capability to simulate dynamic data, setting the stage for further route optimization and waste analysis.

4(a) Main Menu Display: Preparing for Waste Location Analysis

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 20:49:24 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 2
```

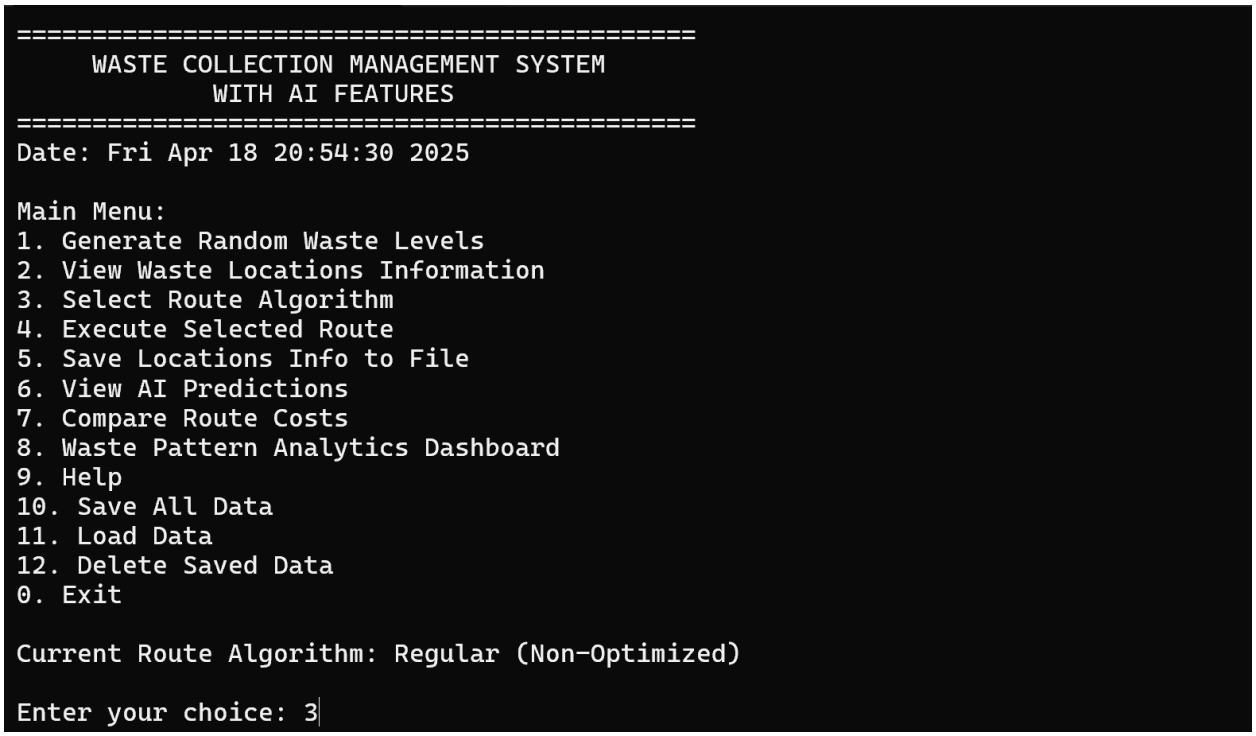
Description: This screenshot captures the system's main menu interface just before the user selects option 2, "View Waste Locations Information." It provides an overview of the accessible features, including generating waste levels, route optimization, AI predictions, and analytics. The clear prompt for user input ensures seamless navigation and interaction.

4(b) Waste Location Details: Real-Time Information at a Glance

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 20:51:31 2025
================================================
        Current Waste Locations Information
================================================
Location                    Waste Level %       AI Prediction (24h)      Trend
------------------------------------------------------------------------------------------
Kuala Lumpur Central        39 %                31 %                     Stable
Petaling Jaya               53 %                23 %                     Stable
Shah Alam                   99 %                0 %                      Stable
Subang Jaya                 15 %                43 %                     Stable
Ampang                      18 %                12 %                     Stable
Klang                       6 %                 29 %                     Stable
Cheras                      95 %                20 %                     Stable
Puchong                     62 %                41 %                     Stable
Putrajaya                   74 %                29 %                     Stable
Cyberjaya                   69 %                10 %                     Stable
================================================
Press any key to continue . . .
```

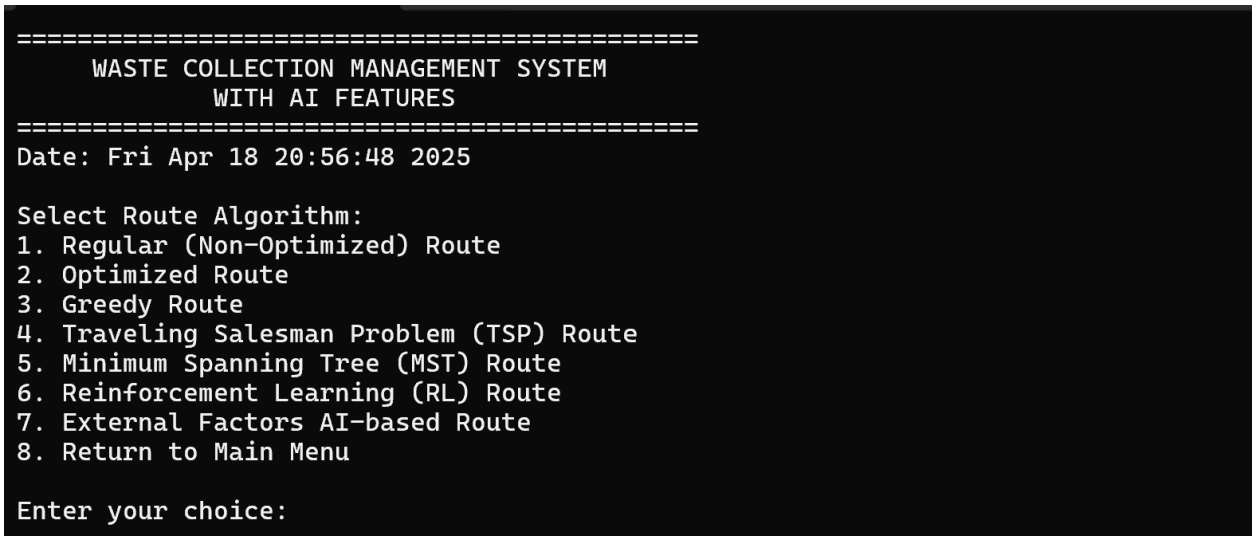
Description: After selecting option 2, the system presents a detailed table summarizing the current waste levels, AI-predicted levels for the next 24 hours, and trends for key locations like Kuala Lumpur Central, Petaling Jaya, and others. This data-centric display reflects the project's analytical focus, offering insights into waste accumulation and stability across regions to facilitate informed decision-making.

5(a) Route Algorithm Selection: Optimizing Waste Management



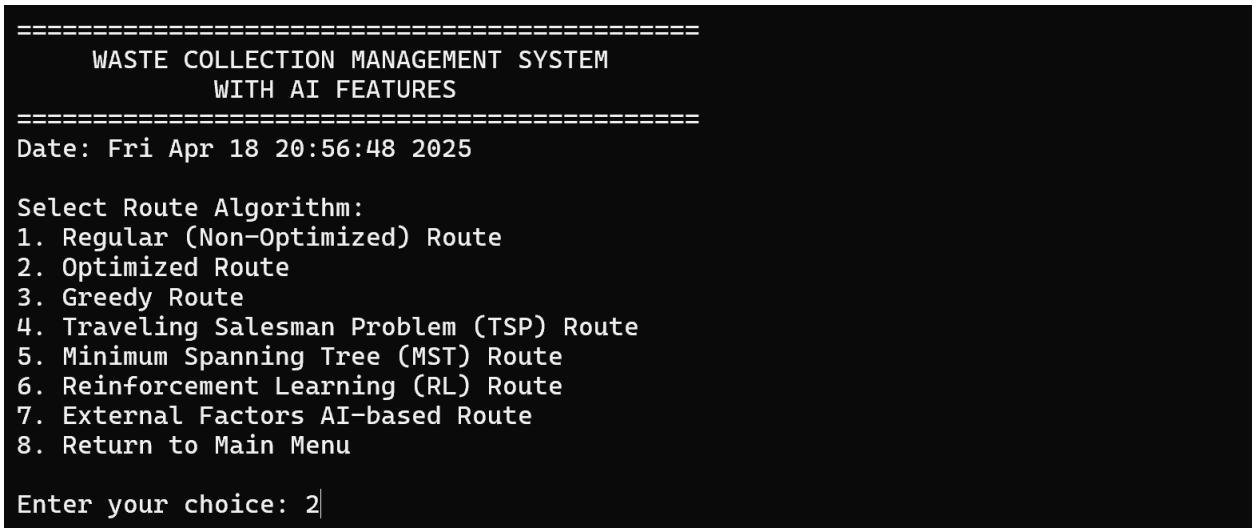
Description: This screenshot shows the user selecting option 3, "Select Route Algorithm," from the main menu. This crucial step allows the user to switch between different route optimization techniques to improve efficiency in waste collection. The current route algorithm, displayed as "Regular (Non-Optimized," is about to be updated for more advanced functionalities tailored to real-world scenarios.

5(b) Advanced Route Algorithm Selection: Tailoring Efficiency



Description: Following the user's selection of option 3, the interface transitions to the route algorithm menu, showcasing an array of methodologies from basic approaches like Regular Route to advanced algorithms such as Reinforcement Learning (RL) and AI-based routes factoring external variables. This comprehensive selection underscores the project's flexibility in adapting to diverse waste management challenges, empowering users to choose the optimal strategy for their needs.

5(c) Optimized Route Algorithm Selected: Enhancing Waste Collection Efficiency



Description: This screenshot illustrates the moment when the user selects option 2, "Optimized Route," from the Route Algorithm menu. The system is now set to apply the Optimized Route methodology, improving the efficiency and effectiveness of waste collection operations. This marks a pivotal step in streamlining waste management for better results.

5(d) Route Algorithm Updated to Optimized: Efficiency in Action

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:01:00 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Optimized

Enter your choice:
```

Description: The system has successfully switched the current route algorithm to "Optimized." This adjustment marks a significant enhancement in waste collection efficiency, utilizing advanced methodologies to streamline operations and ensure better resource allocation. The change is now reflected on the main menu, signaling readiness for the next steps in waste management.

*** Repeat 5(a) - 5(d) to change the “Current Route Algorithm***

6(a) Executing Selected Route:

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:05:07 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 4
```

Description: This screenshot captures the moment when the user selects option 4, "Execute Selected Route," from the main menu. The system proceeds to implement the chosen route algorithm, which is currently set to "Regular (Non-Optimized)." This pivotal step reflects the program's ability to translate selected algorithms into actionable waste collection strategies, ensuring practical application and efficiency

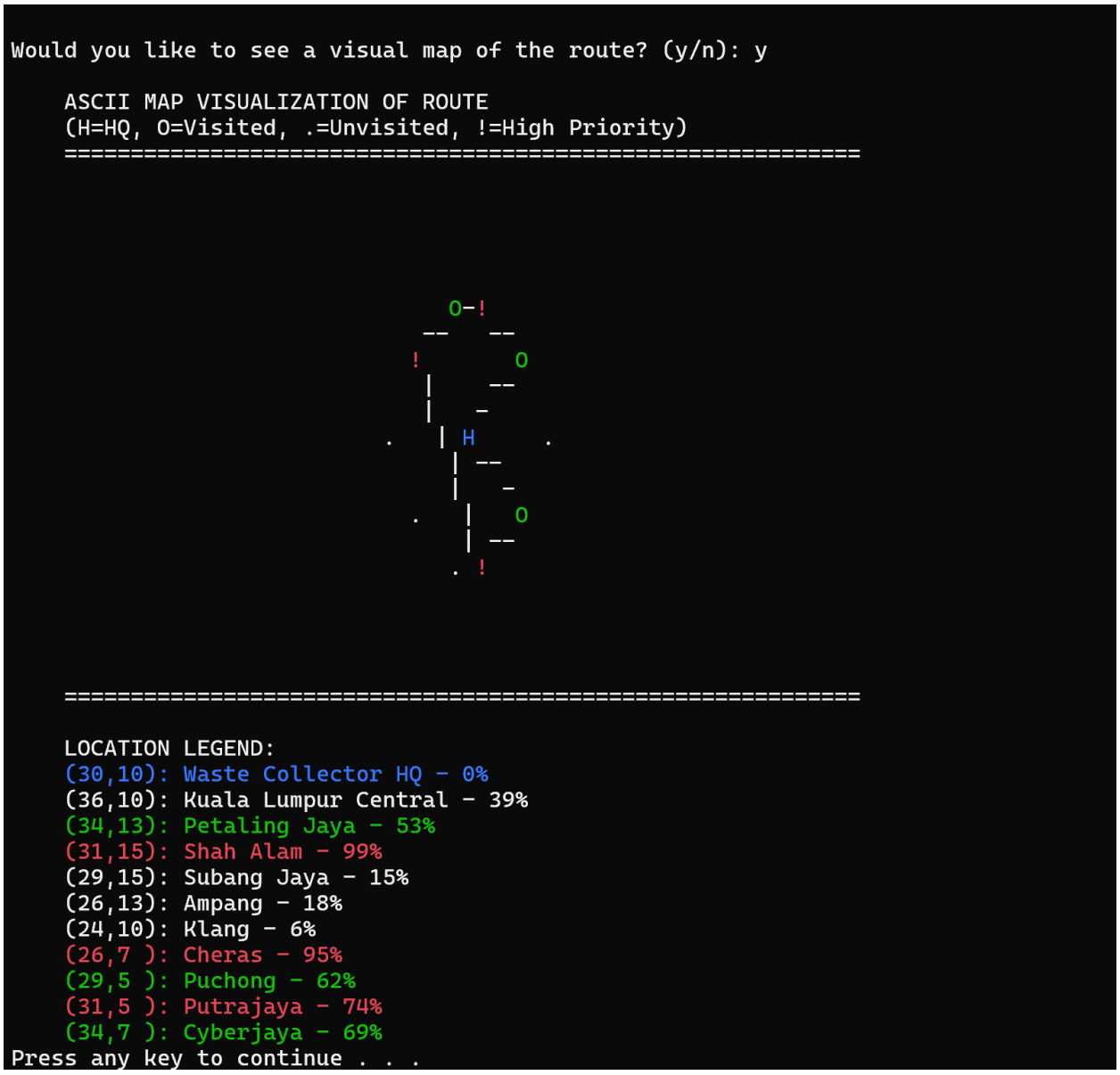
6(b) Route Execution: Strategy in Motion

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:09:37 2025
Calculating optimal route... .....
Route calculation complete!

Regular (Non-Optimized) Route Information
==========================================
Complete Route: Waste Collector HQ -> Petaling Jaya -> Shah Alam -> Cheras -> Puchong -> Putrajaya -> Cyberjaya -> Waste Collector HQ

Route Costs Summary:
Total Distance: 108 km
Total Time: 2.7 hours
Total Fuel Cost: 270 RM
Total Wages: 27 RM
Total Cost: 297 RM
==========================================

Would you like to see a visual map of the route? (y/n):
```

Description: This screenshot captures the system executing the selected route algorithm after the user confirms their choice by pressing enter for option 4, "Execute Selected Route." The output includes a detailed summary of the Regular

(Non-Optimized) route, listing key locations such as Waste Collector HQ, Petaling Jaya, and Shah Alam. A cost breakdown for distance, time, fuel, and wages accompanies the route overview, reflecting the system's analytical capabilities to provide actionable insights for waste collection operations.

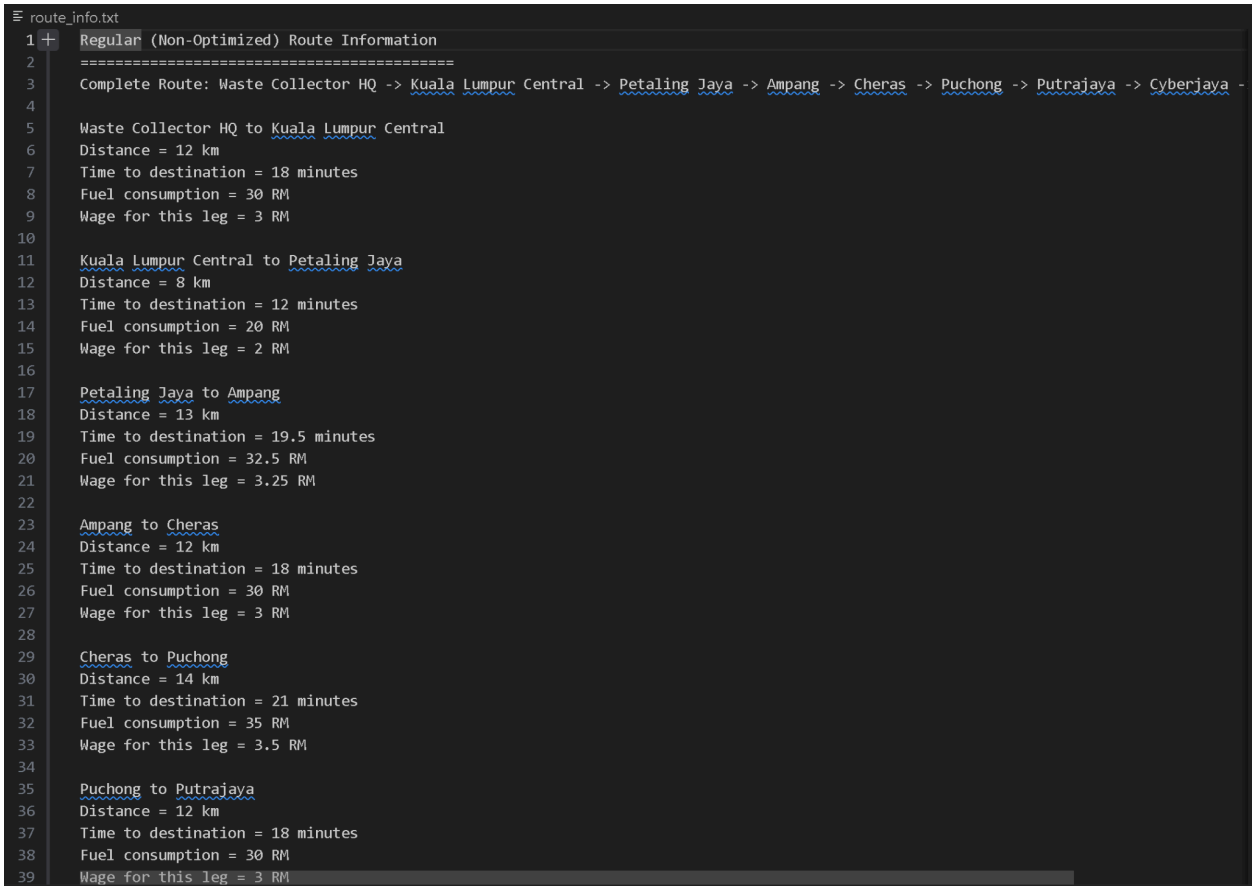
6(c) Visual Route Execution: ASCII Map Generation



Description: This screenshot captures the system generating an ASCII map after the user presses 'y' during route execution. The map visually represents key locations and their statuses, using symbols such as 'H' for the HQ, 'O' for visited areas, '.' for unvisited regions, and '!' for high-priority locations. Accompanied by a detailed legend and

coordinates, this feature enhances clarity and planning in waste management operations.

6(d) Route Information Exported: Documentation for Efficiency



route_info.txt

```
Regular (Non-Optimized) Route Information
==========================================
Complete Route: Waste Collector HQ -> Kuala Lumpur Central -> Petaling Jaya -> Ampang -> Cheras -> Puchong -> Putrajaya -> Cyberjaya -

Waste Collector HQ to Kuala Lumpur Central
Distance = 12 km
Time to destination = 18 minutes
Fuel consumption = 30 RM
Wage for this leg = 3 RM

Kuala Lumpur Central to Petaling Jaya
Distance = 8 km
Time to destination = 12 minutes
Fuel consumption = 20 RM
Wage for this leg = 2 RM

Petaling Jaya to Ampang
Distance = 13 km
Time to destination = 19.5 minutes
Fuel consumption = 32.5 RM
Wage for this leg = 3.25 RM

Ampang to Cheras
Distance = 12 km
Time to destination = 18 minutes
Fuel consumption = 30 RM
Wage for this leg = 3 RM

Cheras to Puchong
Distance = 14 km
Time to destination = 21 minutes
Fuel consumption = 35 RM
Wage for this leg = 3.5 RM

Puchong to Putrajaya
Distance = 12 km
Time to destination = 18 minutes
Fuel consumption = 30 RM
Wage for this leg = 3 RM
```

Description: Upon executing the selected route, the system automatically generates a `route_info.txt` file. This file contains detailed data about the route, including location details, cost breakdowns, distance calculations, and additional parameters crucial for waste management analysis. The export feature ensures accessibility for record-keeping and further optimization.

*****Repeat 6(a) - 6(d) after changing “Current Route Algorithm” *****

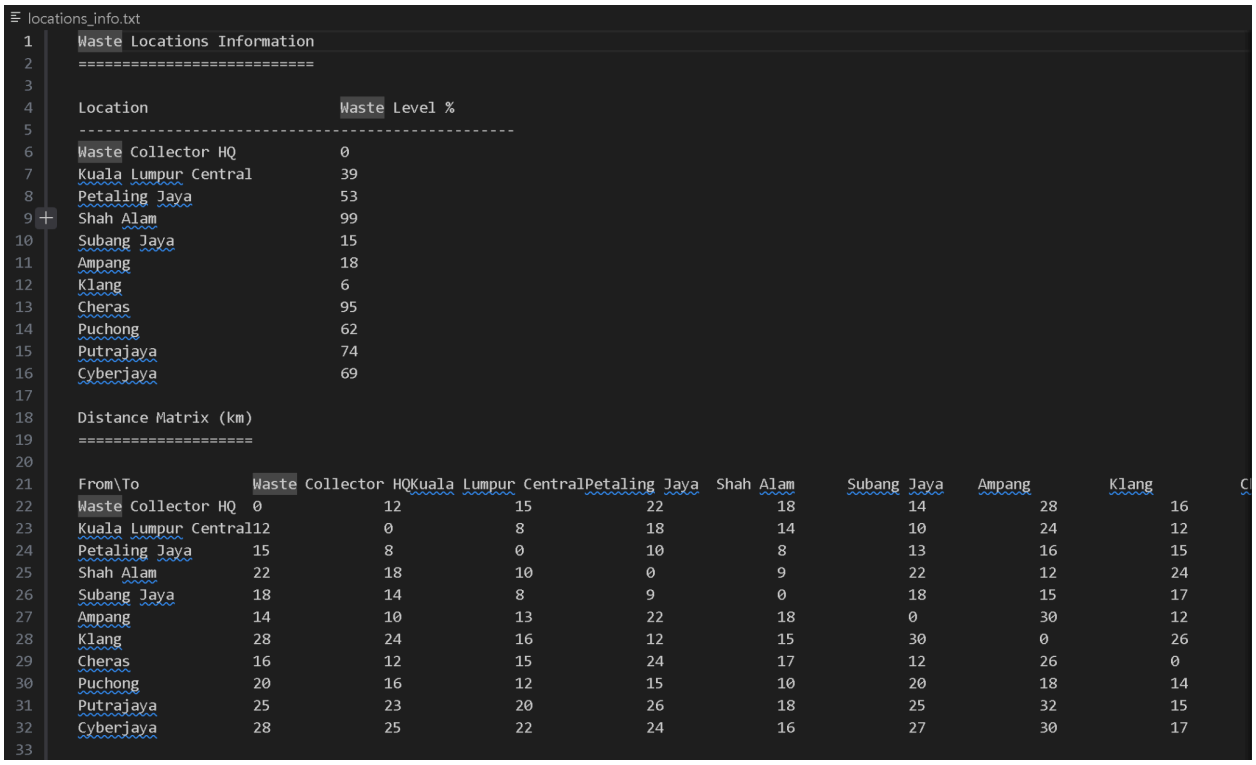
***** Follow 5(a) - 5(d) to change “Current Route Algorithm*****

7(a) Data Export: Locations Information Successfully Saved

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:13:02 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 5

SUCCESS: Locations info saved to 'locations_info.txt'
Press any key to continue . . .
```

Description: This screenshot captures the moment the user selects option 5, "Save Locations Info to File," from the main menu. The system confirms the successful creation of a `locations_info.txt` file, securely storing crucial information about waste locations. This feature highlights the project's emphasis on data preservation, enabling users to maintain accurate records for future reference and analysis.

7(b) Waste Locations Data: Comprehensive Overview



locations_info.txt

```
Waste Locations Information
==========================

Location                    Waste Level %
--------------------------------------------------
Waste Collector HQ          0
Kuala Lumpur Central        39
Petaling Jaya               53
Shah Alam                   99
Subang Jaya                 15
Ampang                      18
Klang                       6
Cheras                      95
Puchong                     62
Putrajaya                   74
Cyberjaya                   69

Distance Matrix (km)
====================

From\To             Waste Collector HQKuala Lumpur CentralPetaling Jaya  Shah Alam      Subang Jaya    Ampang         Klang          C
Waste Collector HQ  0               12              15              22              18             14             28             16
Kuala Lumpur Central12              0               8               18              14             10             24             12
Petaling Jaya       15              8               0               10              8              13             16             15
Shah Alam           22              18              10              0               9              22             12             24
Subang Jaya         18              14              8               9               0              18             15             17
Ampang              14              10              13              22              18             0              30             12
Klang               28              24              16              12              15             30             0              26
Cheras              16              12              15              24              17             12             26             0
Puchong             20              16              12              15              10             20             18             14
Putrajaya           25              23              20              26              18             25             32             15
Cyberjaya           28              25              22              24              16             27             30             17
```

Description: This screenshot captures the contents of the `locations_info.txt` file generated by the Waste Management system. It includes a detailed list of waste levels, expressed as percentages, for locations such as Kuala Lumpur Central, Shah Alam, and Putrajaya. Additionally, a distance matrix outlines the distances (in kilometers) between the Waste Collector HQ and various locations, enabling thorough planning and analysis for waste collection routes. This file serves as an essential tool for record-keeping and optimizing waste management strategies.

8(a) AI Predictions in Action: Insights That Drive Decisions

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:26:22 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 6
```

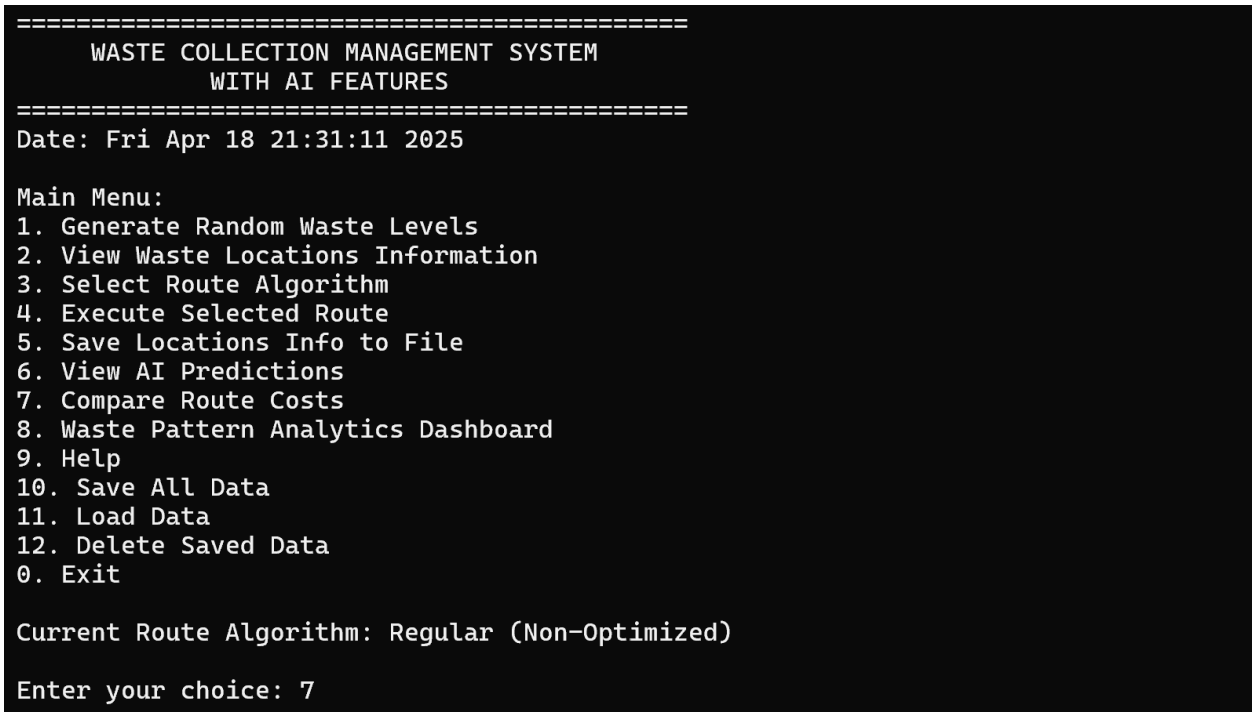
Description: When the user selects option 6, "View AI Predictions," the system accesses advanced analytics powered by AI. This feature presents a detailed analysis, including real-time waste levels, predictive trends for the next 24 hours, and actionable insights across key locations. By leveraging AI, this functionality empowers users to make informed, data-driven decisions for efficient waste management

8(b) AI Predictions Table: Real-Time Trends Revealed

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:28:05 2025

AI Predictions for Waste Levels:
================================================================================
Would you like to simulate trending waste levels? (y/n): y
Trending waste levels simulated.

Location              Current %       24 Hours %      48 Hours %      72 Hours %      Trend
--------------------  --------------  --------------  --------------  --------------  --------------------
Kuala Lumpur Central  39 %            0 %             0 %             0 %             Stable
Petaling Jaya         53 %            0 %             0 %             0 %             Stable
Shah Alam             99 %            54 %            54 %            54 %            Stable [ANOMALY]
Subang Jaya           15 %            0 %             0 %             0 %             Stable
Ampang                18 %            0 %             0 %             0 %             Stable
Klang                 6 %             0 %             0 %             0 %             Stable [ANOMALY]
Cheras                95 %            95 %            95 %            95 %            Stable
Puchong               62 %            100 %           100 %           100 %           Stable
Putrajaya             74 %            30 %            30 %            30 %            Stable
Cyberjaya             69 %            0 %             0 %             0 %             Stable

Press any key to return to main menu...
```

Description: This screenshot follows the user pressing 'y' after selecting option 6, "View AI Predictions." The system displays a comprehensive table of AI-driven predictions, detailing waste levels across various locations such as Kuala Lumpur Central, Petaling Jaya, and Shah Alam. The table includes columns for current waste percentages, 24-hour, 48-hour, and 72-hour predictions, alongside trend analyses such as "Stable" or "Stable [ANOMALY]." This visual feature enables users to gain precise insights into waste accumulation patterns for informed decision-making.

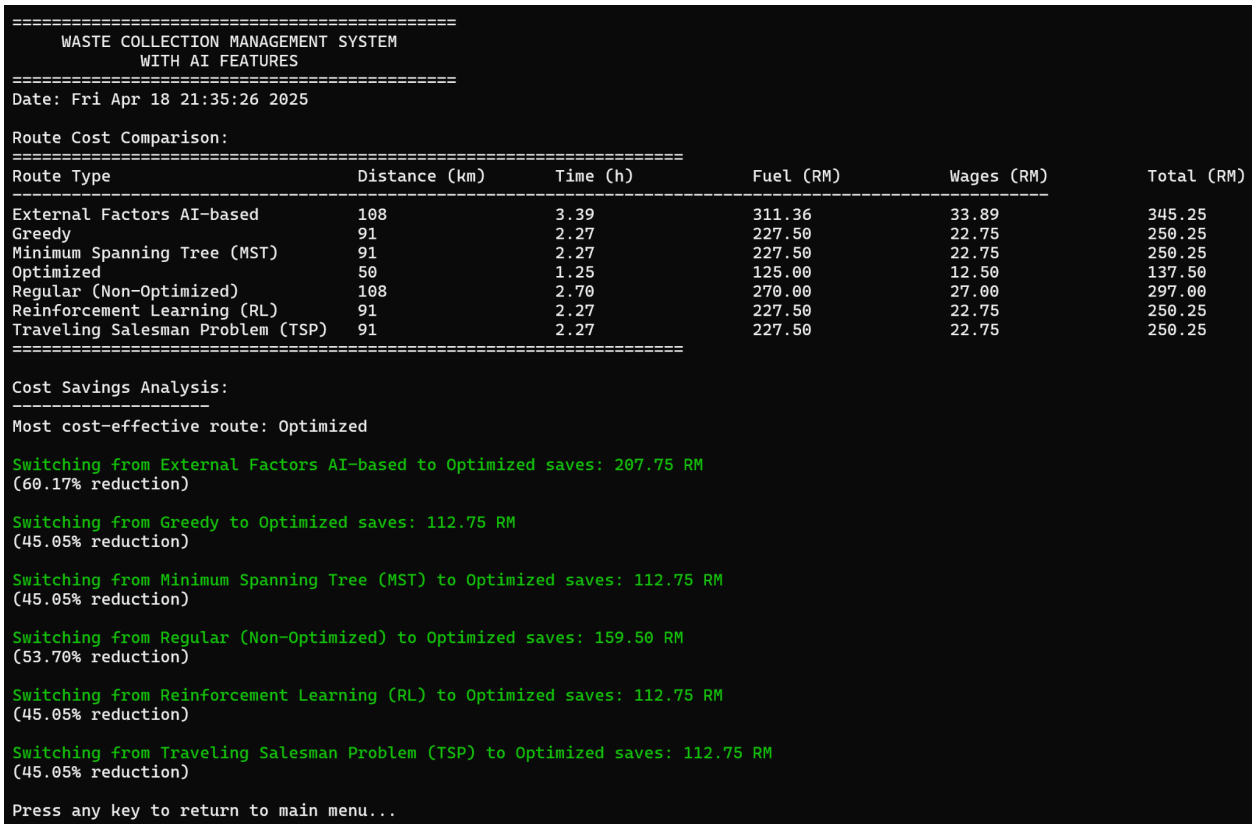
9(a) Comparing Route Costs: Evaluating Efficiency Metrics



Description: This screenshot illustrates the user selecting option 7, "Compare Route Costs," from the main menu. The system transitions to a cost comparison module that evaluates the expenses associated with different route algorithms, including distance, time, fuel consumption, and wages. This feature offers users a clear overview of operational costs, empowering data-driven decisions to optimize waste collection strategies.

*****Execute All Route Option before pressing “Option 7”*****

9(b) Cost Comparison Results: Optimized Efficiency in Focus



```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
            WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:35:26 2025

Route Cost Comparison:
=====================================================================
Route Type                      Distance (km)       Time (h)            Fuel (RM)           Wages (RM)          Total (RM)
---------------------------------------------------------------------------------------------------------------------
External Factors AI-based       108                 3.39                311.36              33.89               345.25
Greedy                          91                  2.27                227.50              22.75               250.25
Minimum Spanning Tree (MST)     91                  2.27                227.50              22.75               250.25
Optimized                       50                  1.25                125.00              12.50               137.50
Regular (Non-Optimized)         108                 2.70                270.00              27.00               297.00
Reinforcement Learning (RL)     91                  2.27                227.50              22.75               250.25
Traveling Salesman Problem (TSP) 91                 2.27                227.50              22.75               250.25
=====================================================================

Cost Savings Analysis:
--------------------
Most cost-effective route: Optimized

Switching from External Factors AI-based to Optimized saves: 207.75 RM
(60.17% reduction)

Switching from Greedy to Optimized saves: 112.75 RM
(45.05% reduction)

Switching from Minimum Spanning Tree (MST) to Optimized saves: 112.75 RM
(45.05% reduction)

Switching from Regular (Non-Optimized) to Optimized saves: 159.50 RM
(53.70% reduction)

Switching from Reinforcement Learning (RL) to Optimized saves: 112.75 RM
(45.05% reduction)

Switching from Traveling Salesman Problem (TSP) to Optimized saves: 112.75 RM
(45.05% reduction)

Press any key to return to main menu...
```

Description: This screenshot showcases the detailed output of the "Compare Route Costs" feature after the user selects option 7. The system presents a comprehensive table comparing various route algorithms such as Regular (Non-Optimized), Optimized, Minimum Spanning Tree (MST), and more. Key metrics include distance (in km), time (in hours), fuel costs (in RM), wages, and total cost. Additionally, the Cost Savings Analysis highlights the benefits of switching to the Optimized route, emphasizing significant reductions in total costs and percentages across different algorithms. This feature offers invaluable insights for refining waste collection strategies and minimizing operational expenses.

10(a) Waste Pattern Analytics Dashboard: Visualizing Trends and Insights

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:39:55 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 8
```

Description: This screenshot captures the moment the user selects option 8, "Waste Pattern Analytics Dashboard," from the main menu. The system prepares to transition to an advanced feature that visualizes waste accumulation patterns, presenting graphs, charts, and analytical summaries. This dashboard empowers users to identify trends, anomalies, and efficiency bottlenecks, driving smarter decision-making in waste management strategies.

10(b) Waste Pattern Analytics Dashboard: Advanced Insights Unveiled

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:41:50 2025

================================================================
               WASTE PATTERN ANALYTICS DASHBOARD
================================================================

----- SUMMARY STATISTICS -----
Average Waste Level:               53.00%
High Priority Locations:           3
Detected Anomalies:                2

----- WASTE PATTERN ANALYSIS -----
Location                 Current %      Trend          Days to Capacity    Pattern Type
-------------------------------------------------------------------------------------------
Kuala Lumpur Central     39 %           Stable         28                  Consistent
Petaling Jaya            53 %           Stable         21                  Moderate Variability
Shah Alam                99 %           Stable         0                   Consistent [ANOMALY]
Subang Jaya              15 %           Stable         40                  Consistent
Ampang                   18 %           Stable         39                  Moderate Variability
Klang                    6 %            Stable         45                  Consistent [ANOMALY]
Cheras                   95 %           Stable         0                   Consistent
Puchong                  62 %           Stable         17                  Moderate Variability
Putrajaya                74 %           Stable         11                  Consistent
Cyberjaya                69 %           Stable         13                  Highly Variable

----- WASTE TREND VISUALIZATION -----
Top Waste Growth Locations:
   No significant growth trends detected

----- INSIGHTS & RECOMMENDATIONS -----
ΓÇó URGENT: 3 location(s) require immediate attention
ΓÇó 3 location(s) should be scheduled within the next 48 hours
ΓÇó Anomalies detected at: Shah Alam, Klang
  Recommend investigation of sudden waste level changes
ΓÇó Recommendation: Increase collection frequency for high-priority areas
```

Description: This screenshot reveals the detailed output of the "Waste Pattern Analytics Dashboard" after the user presses option 8. The system displays comprehensive statistics, including average waste levels, anomalies detected, and high-priority locations requiring immediate attention. A table outlines waste levels, stability trends, and days to capacity for each location, supplemented by visualizations of top waste growth trends. Accompanied by actionable recommendations for critical areas like Shah Alam and Klang, this feature empowers users to optimize their waste management strategies with precision.

10(c) ASCII Map for Waste Management Analysis: Route Visualization in

Action

Description: This continuation screenshot, part of the "Waste Pattern Analytics Dashboard" after choosing option 8, displays an ASCII map. The map represents waste collection routes with symbols denoting 'H' for Waste Collector HQ, 'O' for locations already visited, '.' for unvisited locations, and '!' for high-priority areas. Accompanying this visual is a legend that lists coordinates and names alongside waste percentages, providing a comprehensive spatial analysis essential for optimizing routes and resource allocation.

11(a) Main Menu Interface: Help Function

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:50:13 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 9
```

Description: This screenshot shows the system's main menu interface before the user selects option 9, "Help." The Help Function is to elaborate on the purpose and use cases of options such as generating random waste levels, viewing location data, selecting and executing route algorithms, exporting information to files, comparing route costs, and accessing AI-driven predictions. The descriptions aim to ensure users fully understand the capabilities and practical applications of each feature, enabling efficient navigation and operation of the system.

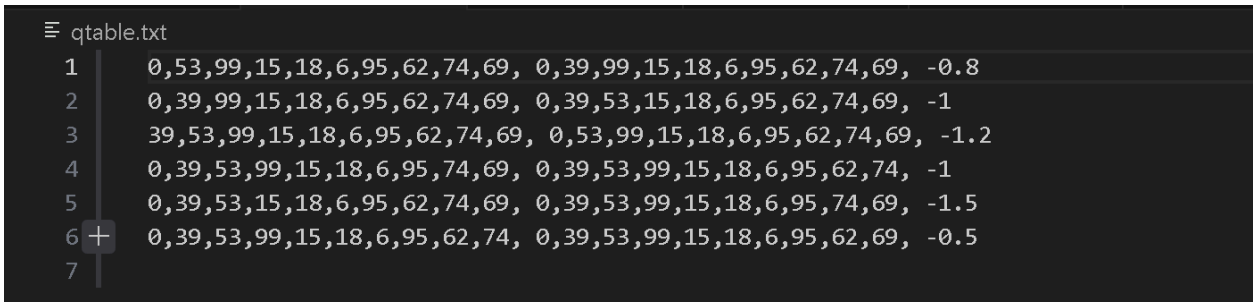
11(b) Help Menu: Comprehensive System Guidance

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 21:45:58 2025

==========================================
          HELP DOCUMENTATION
==========================================

1. Generate Random Waste Levels:
   Simulates real-world data by generating random waste levels (0-100%)
   for all collection locations. Use this to test different scenarios.

2. View Waste Locations Information:
   Displays all waste collection locations with their current waste levels,
   AI predictions for the next 24 hours, and trend analysis.
   - Green: Low waste levels (<40%)
   - Yellow: Medium waste levels (40-69%)
   - Red: High waste levels (70%+)

3. Select Route Algorithm:
   Choose from 5 different routing algorithms:
   - Regular: Visits locations with waste level ΓëÑ40% within 30km
   - Optimized: Visits locations with waste level ΓëÑ60% within 20km
   - Greedy: Visits locations with waste level ΓëÑ30%, always choosing
     the nearest location next
   - TSP: Visits locations with waste level ΓëÑ25% using the Traveling
     Salesman Problem algorithm to find the shortest path
   - MST: Visits locations with waste level ΓëÑ35% using a Minimum
     Spanning Tree to find an efficient route
   - RL: Visits locations with waste level ΓëÑ30% using Reinforcement
     Learning to optimize the route based on past experiences
   - External Factors AI-based: Optimizes routes based on external factors

4. Execute Selected Route:
   Calculates and displays the optimized collection route using the
   selected algorithm. Shows distance, time, fuel cost, and wage cost.
   The route information is also saved to 'route_info.txt'.

5. Save Locations Info to File:
   Exports the current waste location data to 'locations_info.txt',
   including waste levels, predictions, and distances.
```

```
6. View AI Predictions:
   Shows AI-powered predictions for waste levels over the next 72 hours.
   Includes trend analysis and anomaly detection.
   You can also simulate trending waste data for demonstrations.

7. Compare Route Costs:
   Compares the costs of different routing algorithms side by side,
   showing potential savings by switching to the most cost-effective route.
   You need to execute at least 2 different routes to use this feature.

8. Waste Pattern Analytics Dashboard:
   Comprehensive dashboard that analyzes historical waste data,
   identifies patterns, and provides actionable insights including:
   - Days until bins reach capacity
   - Waste pattern classification
   - Trend visualization
   - Prioritized recommendations

9. Help: Display this help information

10. Save All Data:
   Saves all current waste data, including locations, waste levels,
   historical data, and distance matrix to a binary file.
   This allows you to restore your data when restarting the application.

11. Load Data:
   Loads previously saved waste data from a binary file.
   This restores all locations, waste levels, historical data, and distances.

12. Delete Saved Data:
   Permanently deletes a saved data file.
   Use with caution as this operation cannot be undone.

0. Exit: Close the application

=== ADDITIONAL INFORMATION ===
- Cost calculations include both fuel (RM 2.50/km) and driver wages (RM 10.00/hour)
- Anomalies are detected when waste levels deviate significantly from historical trends
- All routes begin and end at the Waste Collector HQ
- Your data is saved to 'waste_data.dat' by default

Press any key to return to the main menu...
```

Description: After selecting option 9, "Help," the system displays a detailed guide summarizing the functionalities of the Waste Collection Management System. The help menu outlines key options, including generating random waste levels, viewing waste location information, selecting and executing route algorithms, saving location data to file, and comparing costs. Each description includes examples and real-world applications, empowering users to navigate and utilize the system effectively.

12. Q-Table File Generated: Reinforcement Learning in Action



Description: This screenshot showcases the contents of the `qtable.txt` file, which is automatically created when the user changes the route algorithm to "Reinforcement Learning Route." The file contains a Q-table—an essential component of the reinforcement learning process—consisting of rows of state-action pairs and their associated Q-values. These numerical values represent the expected rewards for taking specific actions in given states, enabling the system to refine and optimize waste collection routes dynamically based on learning outcomes.

This file will only be generated when user chooses to change the "Current Route Algorithm to "Reinforcement Learning Route" and execute it.

*****Refer to 5a-5d and 6a-6d for guidance*****

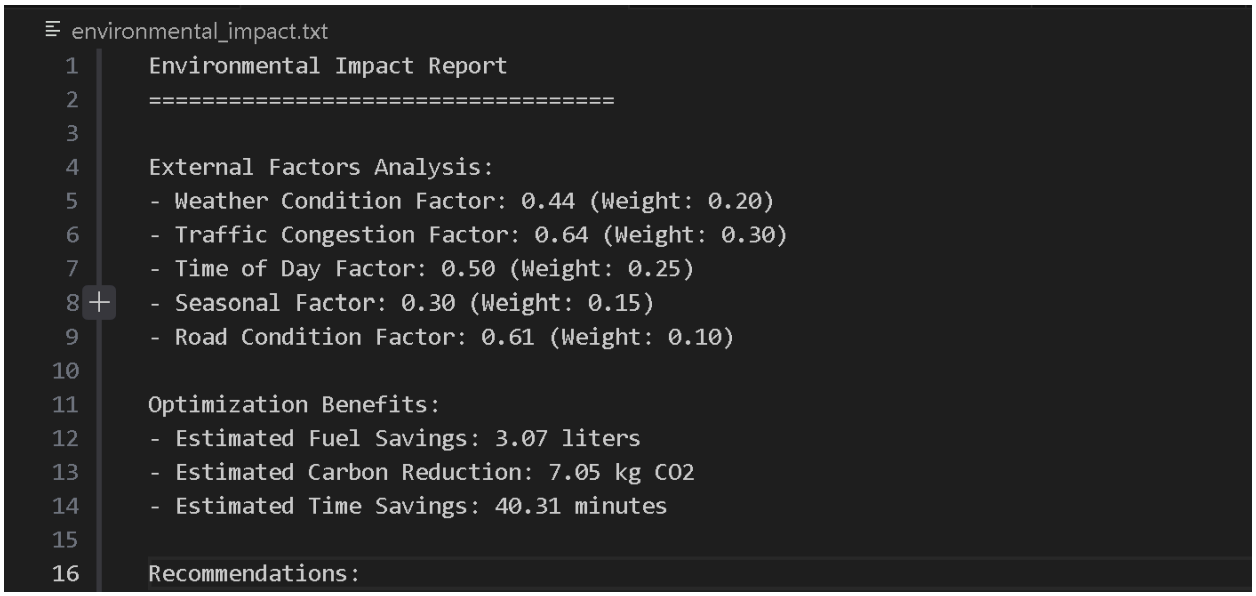
13(a) External Factors History File: AI-Based Route Insights

external_factors_history.dat

```
Cyberjaya 0.44 0.64 0.5 0.3 0.606
Putrajaya 0.44 0.64 0.5 0.3 0.606
Puchong 0.44 0.64 0.5 0.3 0.606
Cheras 0.44 0.64 0.5 0.3 0.606
Klang 0.44 0.64 0.5 0.3 0.606
Kuala Lumpur Central 0.44 0.64 0.5 0.3 0.606
Subang Jaya 0.44 0.64 0.5 0.3 0.606
Petaling Jaya 0.44 0.64 0.5 0.3 0.606
Shah Alam 0.44 0.64 0.5 0.3 0.606
Waste Collector HQ 0.44 0.64 0.5 0.3 0.606
Ampang 0.44 0.64 0.5 0.3 0.606

```

Description: This screenshot captures the `external_factors_history.dat` file, generated when the user selects the "External Factor AI-Based Route" algorithm. The file logs detailed data for various locations, including numerical values representing external factors like traffic conditions, weather influence, and waste accumulation patterns. Locations such as Cyberjaya, Putrajaya, and Kuala Lumpur Central are listed alongside their respective metrics, enabling comprehensive analysis for route optimization. This feature demonstrates the system's capability to incorporate dynamic real-world factors into AI-driven decision-making for waste collection strategies.

13(b) Environmental Impacts Report: AI-Driven Optimization



Description: This screenshot showcases the contents of the `environmental_impacts.txt` file, generated when the user selects the "External Factors AI-Based Route." The report provides an in-depth analysis of external factors influencing waste collection, including weather conditions, traffic congestion, time of day, seasonal variations, and road conditions. Each factor is accompanied by its respective value and weight, highlighting their impact on route efficiency. Additionally, the file outlines optimization benefits such as estimated fuel savings, carbon reduction, and time savings, emphasizing the environmental advantages of adopting AI-driven strategies.

These 2 files will only be generated when user chooses to change the Current Route Algorithm to “External Factors AI- Based Route” and executing the route.

*****Refer to 5a-5d and 6a-6d for guidance*****

14(a) Data Preservation: Saving All System Information

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
              WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:05:18 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 10
```

Description: This screenshot captures the moment the user selects option 10, "Save All Data," from the main menu. The system initiates a comprehensive data preservation process, securely saving all relevant information, including waste levels, route algorithms, cost comparisons, and AI predictions, into designated files. This feature ensures that all critical data is archived for future reference, enabling seamless continuity and analysis in waste management operations.

14(b) Save Data Options: Flexibility in File Management

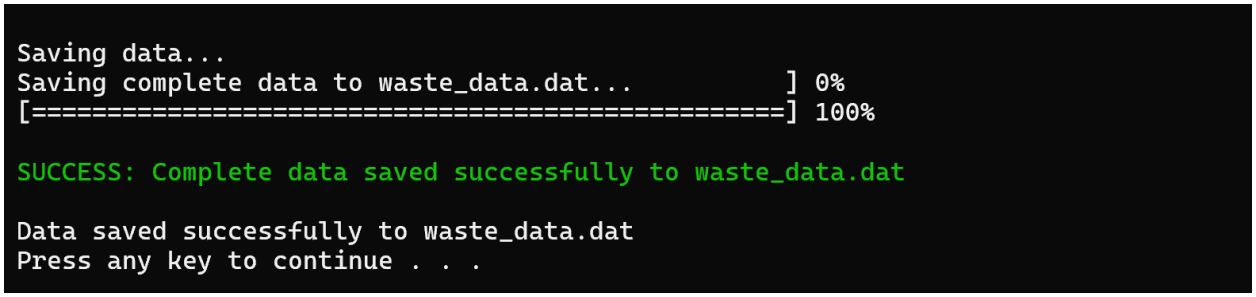
```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
              WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:06:54 2025

Save Data Options:
1. Save to default file (waste_data.dat)
2. Save to a custom file
3. Return to main menu

Enter your choice:
```

Description: This screenshot showcases the data-saving interface of the Waste Collection Management System. After selecting option 10, "Save All Data," the system presents three choices for file management:

1. Save to the default file (`waste_data.dat`)
2. Save to a custom file, allowing personalized naming for organization
3. Return to the main menu without saving data

The user is prompted to enter their choice, offering flexibility in data preservation to suit individual requirements. This intuitive feature streamlines data handling for effective waste management operations

14(c) Data Saved to Default File: waste_data.dat



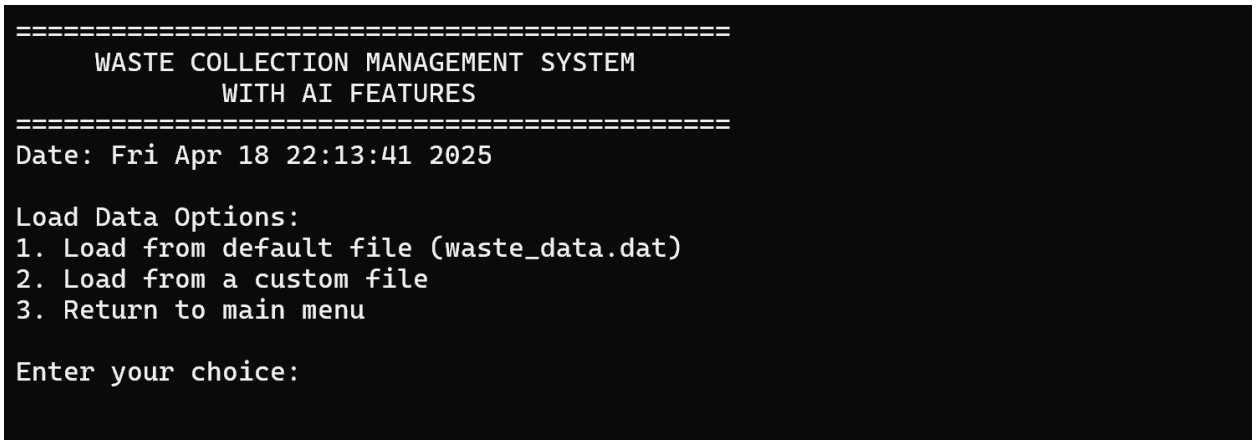
Description: This screenshot captures the system's process of saving all relevant data to the default file, `waste_data.dat`, as the user selects option 1. The console output confirms successful data preservation with a progress bar, starting at 0% and completing at 100%, followed by the message: "SUCCESS: Complete data saved successfully to waste_data.dat." This ensures secure archiving of waste levels, route algorithms, cost breakdowns, and predictions for future use and analysis. The system then prompts the user with "Press any key to continue."

15(a) Data Load: Restoring Saved System Information

```
============================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
============================================
Date: Fri Apr 18 22:11:43 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 11
```

Description: After exiting and rerunning the Waste Collection Management System, the user selects option 11, "Load Data." This screenshot captures the system's process of retrieving data from the default file, `waste_data.dat`. The console confirms successful loading of waste levels, route algorithms, cost breakdowns, AI predictions, and other saved parameters. The system then returns to the main menu, allowing the user to seamlessly continue operations with previously saved data. This feature underscores the system's user-centric approach to data continuity and accessibility.

15(b) Flexible Data Loading: Restore Information from Any File

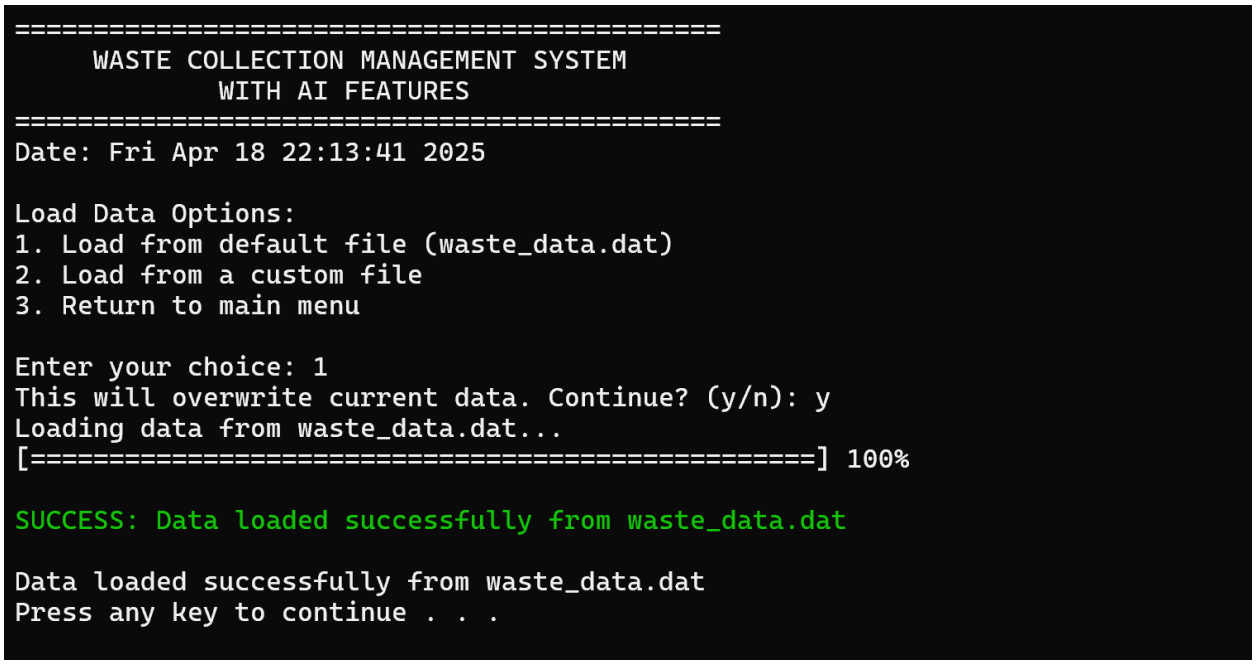


Description: This screenshot captures the data loading interface after the user selects option 11, "Load Data." The system offers three choices:

1. Load from the default file (`waste_data.dat`)
2. Load from a custom file, enabling personalized retrieval
3. Return to the main menu

The user is prompted to specify their selection by entering the corresponding number. This feature allows users to seamlessly access previously saved data, ensuring flexibility and convenience in restoring essential information for waste management operations.

15(c) Default Data Restored: Seamless Workflow Continuity



Description: This screenshot illustrates the user selecting option 1, "Load from default file (waste_data.dat)," from the data-loading menu. The system prompts the user to confirm their choice, cautioning that current data will be overwritten. After the user agrees by entering 'y,' the system displays a progress bar indicating the loading process, which successfully reaches 100%. A confirmation message, "SUCCESS: Data loaded successfully from waste_data.dat," reassures the user of the restored data. The system then guides the user back to the main menu for continued operations with previously saved information.

16(a) Data Deletion: Clearing Saved Information for Fresh Start

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:17:02 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 12
```

Description: This screenshot captures the moment the user selects option 12, "Delete Saved Data," from the main menu.

16(b) Flexible Data Deletion: Managing Saved Files

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:18:37 2025

Delete Data Options:
1. Delete default file (waste_data.dat)
2. Delete a custom file
3. Return to main menu

Enter your choice:
```

Description: This screenshot demonstrates the interface for the "Delete Saved Data" functionality. After selecting option 12, the system offers the user three choices:

1. Delete the default file (`waste_data.dat`)
2. Delete a custom file, allowing removal of files with personalized naming
3. Return to the main menu without deleting any files

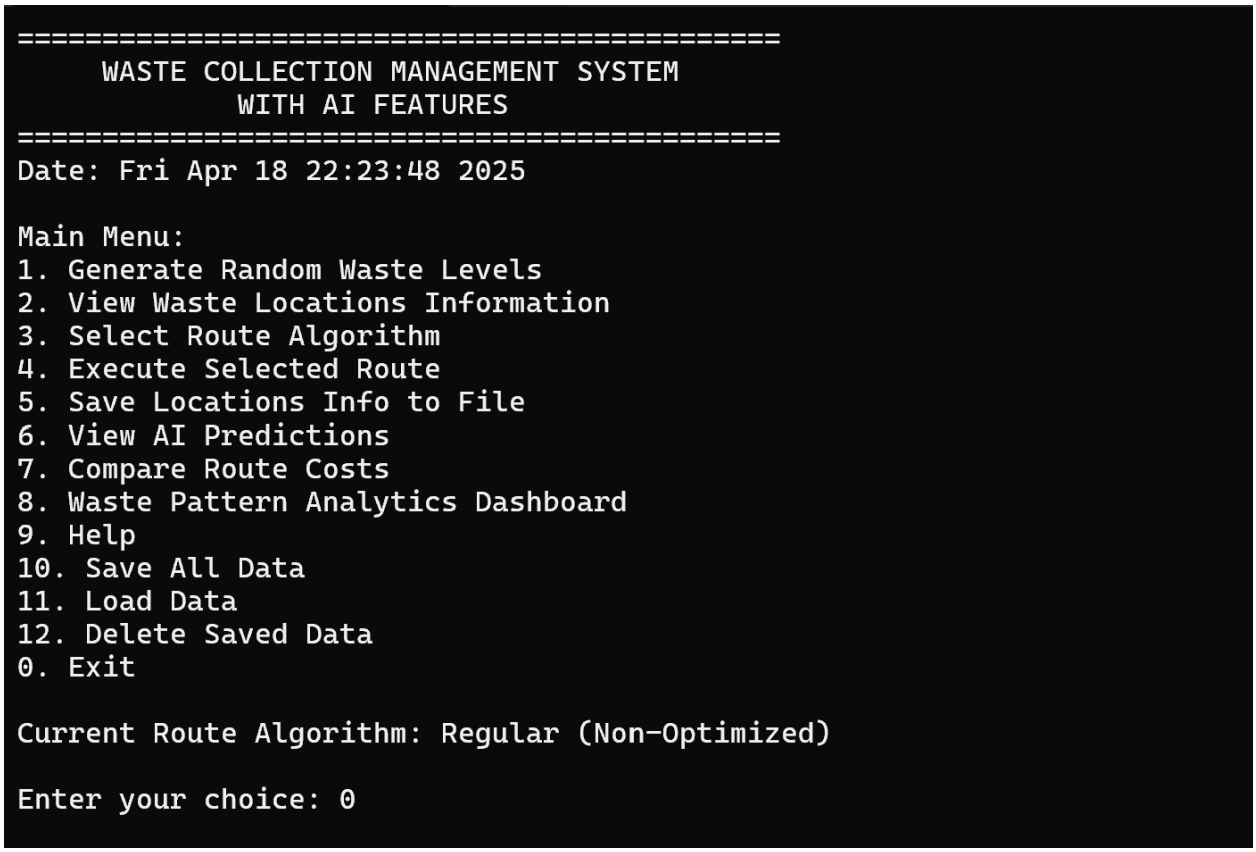
The user is prompted to enter their choice, ensuring complete control over data management and flexibility in organizing or clearing saved information

16(c) File Deletion Completed: Clean Slate Achieved

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
              WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:18:37 2025

Delete Data Options:
1. Delete default file (waste_data.dat)
2. Delete a custom file
3. Return to main menu

Enter your choice: 1
Are you sure you want to delete this file? This cannot be undone. (y/n): y

SUCCESS: Data file deleted successfully: waste_data.dat

Data file deleted successfully
Press any key to continue . . .
```

Description: This screenshot captures the successful deletion of a data file after the user chooses to delete the default file (`waste_data.dat`). Following confirmation with 'y,' the system displays a progress bar tracking the deletion process, which completes at 100%. The console confirms with the message: "SUCCESS: Data file deleted successfully: waste_data.dat," ensuring the user that the operation was carried out securely. The system then prompts with "Press any key to continue," ready to navigate back to the main menu.

17(a) Exit Command Executed: System Shutdown Initiated



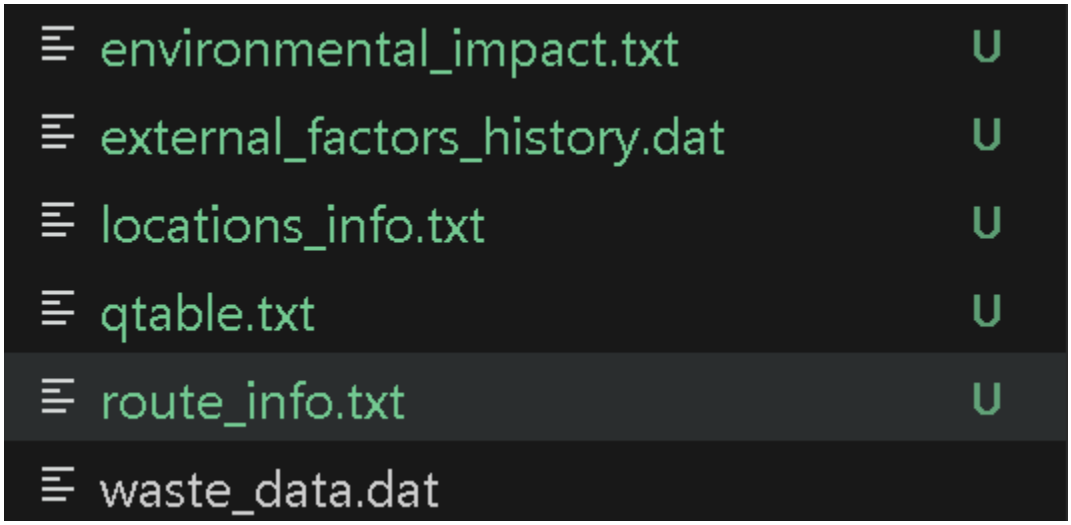
Description: This screenshot captures the user selecting option 0, "Exit," from the main menu of the Waste Collection Management System.

17(b) Exit Confirmation: Save Data Before Closing the System

```
==========================================
     WASTE COLLECTION MANAGEMENT SYSTEM
             WITH AI FEATURES
==========================================
Date: Fri Apr 18 22:23:48 2025

Main Menu:
1. Generate Random Waste Levels
2. View Waste Locations Information
3. Select Route Algorithm
4. Execute Selected Route
5. Save Locations Info to File
6. View AI Predictions
7. Compare Route Costs
8. Waste Pattern Analytics Dashboard
9. Help
10. Save All Data
11. Load Data
12. Delete Saved Data
0. Exit

Current Route Algorithm: Regular (Non-Optimized)

Enter your choice: 0
Are you sure you want to exit? (y/n): y
Do you want to save your data before exiting? (y/n): n
```

Description: This screenshot illustrates the sequence after the user selects option 0, "Exit," from the main menu. The system prompts the user to confirm if they wish to exit by entering 'y' or 'n.' Upon confirmation with 'y,' the system further inquires whether the user wants to save their data before exiting. If the user selects 'y' to save data, the system redirects them to the "Save Data" page, where they can choose between saving to the default file (`waste_data.dat`), saving to a custom file, or returning to the main menu. This feature ensures that no critical data is lost during the exit process, providing a seamless and user-friendly workflow.

18. Comprehensive System Workflow: Files Generated Across Operational Steps



Description: The Waste Collection Management System exemplifies meticulous data handling and operational integrity, as seen in the files created through every step of user interaction. From reinforcement learning route optimization to AI-based environmental analytics, the following files are produced:

1. **environmental_impacts.txt**: A detailed report analyzing external influences like weather, traffic, and road conditions, emphasizing optimization benefits like fuel and carbon savings.
2. **external_factors_history.dat**: Logs numerical data for dynamic external factors, enriching route decision-making with real-world metrics.
3. **locations_info.txt**: Compiles waste levels and distance matrices for systematic and efficient route planning.
4. **qtable.txt**: A reinforcement learning asset containing Q-values for state-action pairs, refining route algorithms through adaptive learning.
5. **route_info.txt**: Provides an organized summary of selected route algorithms and associated costs.
6. **waste_data.dat**: A consolidated archive preserving system data, ensuring continuity in operations and analysis.

Each file represents a critical touchpoint within the system's workflow, underscoring the interplay of AI-driven analytics and user-defined precision in waste management. The workflow seamlessly integrates data generation, utilization, and preservation, catering to dynamic decision-making and environmental sustainability.