ACADEMIC DEFENSE PRESENTATION

The Terroir Brain API

Cultural Demand Forecasting & Waste Reduction System for Tunisian Guest Houses

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Terroir

The Problem: Food Waste Crisis

197 Million USD
Wasted annually across Tunisia's hospitality sector

58%
Organic Waste

Breakfast
Highest Waste Category

ROOT CAUSES

❤ Cultural Tradition
The concept of *Baraka* leads to intentional over-preparation as a sign of generosity.

🌐 Guest Uncertainty
Lack of data on diverse international dietary preferences and consumption habits.
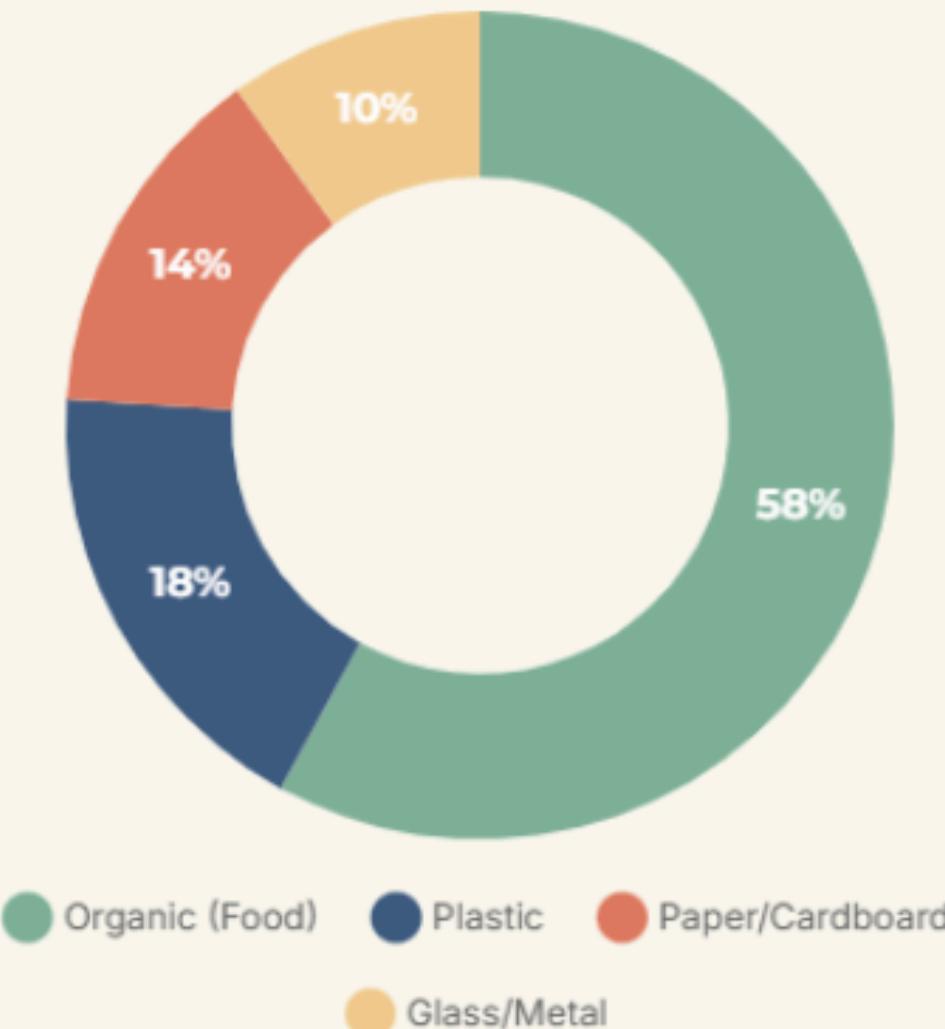
📈 No Forecasting
Reliance on intuition rather than data-driven intelligent tools for planning.

📅 Static Menus
Rigid menu planning that fails to account for seasonality and availability.

Composition of Hospitality Waste

10%
14%
18%
58%

- ● Organic (Food)
- ● Plastic
- ● Paper/Cardboard
- ● Glass/Metal

! Over half of all waste is avoidable organic material, representing a direct financial loss.

The Paradox: Generosity vs Sustainability

Traditional Baraka
Blessing through Abundance

- Hosts prepare abundant food to honor guests properly.
- Deep social expectation of unlimited generosity.
- "Never let a guest leave hungry" is the golden rule.
- Over-preparation is not waste, but a cultural norm.

VS

Modern Challenges
Efficiency & Sustainability

- 9M+ international tourists annually with varied habits.
- Diverse dietary preferences (Vegan, Gluten-free, etc.).
- Rising ingredient costs pressure small business margins.
- Global environmental goals demand waste reduction.

💡 **Core Conflict: How can we preserve hospitality traditions while drastically reducing waste?**

Core Research Question

> "How can we **reduce food waste** in Tunisian guest houses while preserving cultural hospitality traditions and accommodating diverse international guest preferences?"

◎ RESEARCH OBJECTIVES

🌐 Incorporate cultural preferences into forecasting models	🍴 Preserve and codify Tunisian culinary heritage
🔍 Make AI predictions transparent and trustworthy	📈 Deliver measurable impact on waste, cost, & sustainability
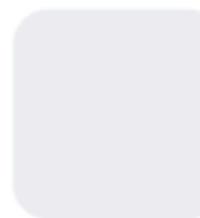
The Solution: Terroir Brain API

Bridging the gap between traditional hospitality and modern efficiency through four core pillars:

Intelligent Forecasting

Multi-factor demand prediction algorithm that accounts for seasonality, occupancy, and guest demographics.
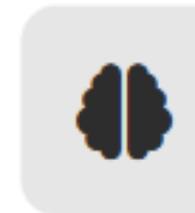
Cultural Menu Generation

Dynamic menu suggestions that honor Tunisian heritage while adapting to international dietary preferences.

Waste Analytics

Deep pattern identification to pinpoint waste sources and provide actionable reduction recommendations.
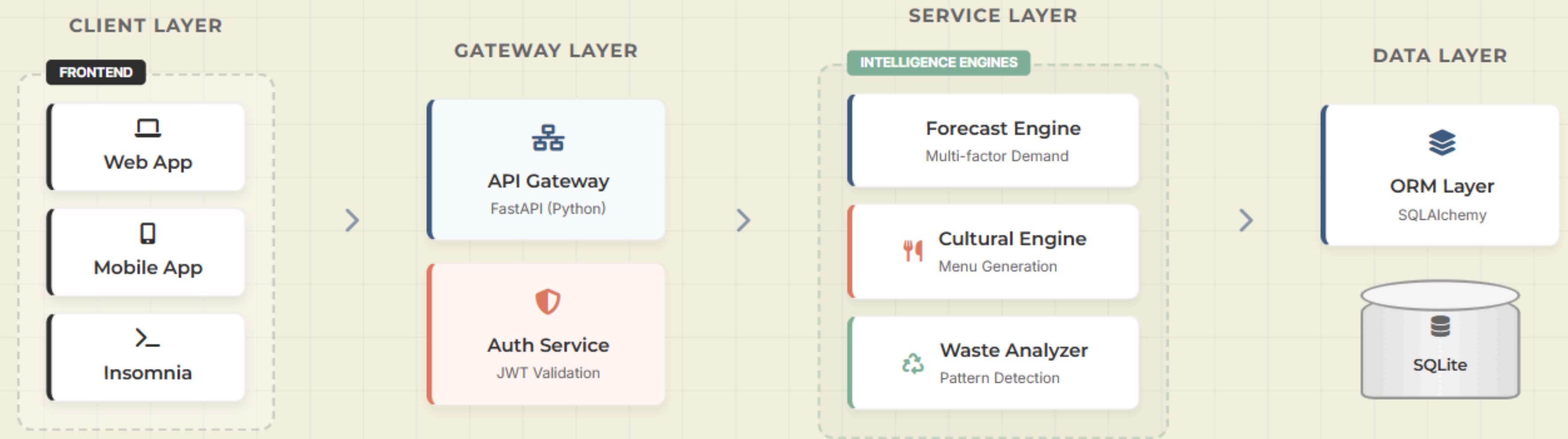
Explainable AI

Fully transparent predictions with calculation breakdowns—building trust through "Glass Box" logic.

A REST API that embeds Tunisian terroir intelligence into every prediction

System Architecture

CLIENT LAYER

FRONTEND

Web App

Mobile App

Insomnia

GATEWAY LAYER

API Gateway
FastAPI (Python)

Auth Service
JWT Validation

SERVICE LAYER

INTELLIGENCE ENGINES

Forecast Engine
Multi-factor Demand

Cultural Engine
Menu Generation

Waste Analyzer
Pattern Detection

DATA LAYER

ORM Layer
SQLAlchemy

SQLite

Containerized Deployment
Isolated microservices environment
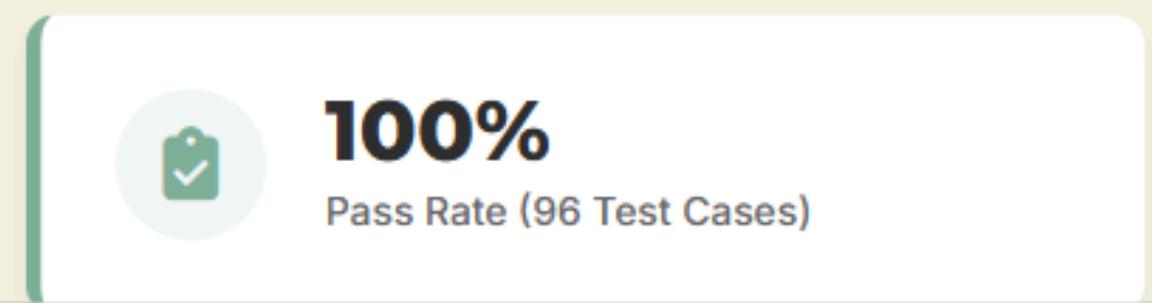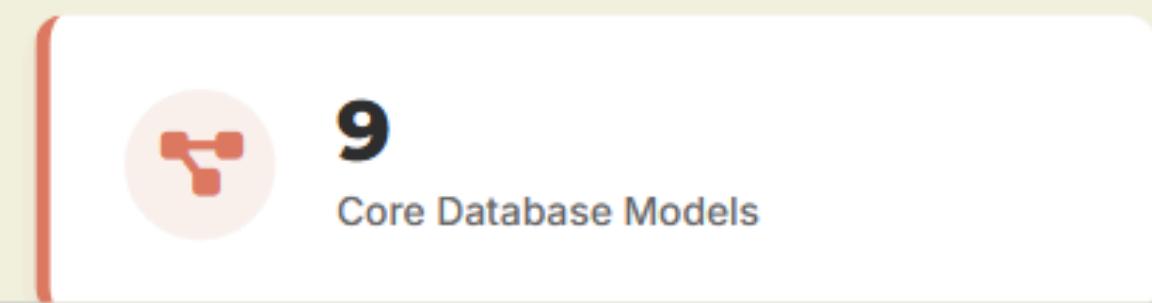
API Server: `0.0.0.0:8000`   Auth Server: `0.0.0.0:8001`

Technology Stack

Layer	Technology	Why Chosen?
Backend	🐍 `FastAPI (Python 3.11)`	High-performance async capabilities, type hinting, and rapid development speed.
Database	🗄 `SQLite + SQLAlchemy`	Powerful ORM for complex relationships; flexible migration path to PostgreSQL.
Validation	✖ `Pydantic v2`	Robust data validation ensuring strict type safety and error handling.
Containerization	🐳 `Docker Compose`	Ensures consistent environments across development, testing, and production.
API Docs	📗 `OpenAPI / Swagger`	Auto-generated, interactive documentation for seamless frontend integration.
Testing	🧪 `Insomnia`	Comprehensive endpoint testing suite for functional and integration tests.

80+
API Endpoints Implemented

9
Core Database Models

100%
Pass Rate (96 Test Cases)

Multi-Factor Forecasting Formula

Demand = $O \times B \times S \times C \times E \times W$

Occupancy — O

Total number of confirmed guests for the meal service.

Range: Integer ≥ 0

Base Rate — B

Standard consumption rate per person for specific ingredient.

Unit: kg/person

Seasonality — S

Adjusts availability and preference based on time of year.

Range: 0.5 – 1.0

Culture — C

Nationality-based preference multiplier for ingredients.

Range: 0.0 – 2.0

Disruption — E

External events like flight delays or cancellations.

Range: 0.0 – 1.0

Waste Adj. — W
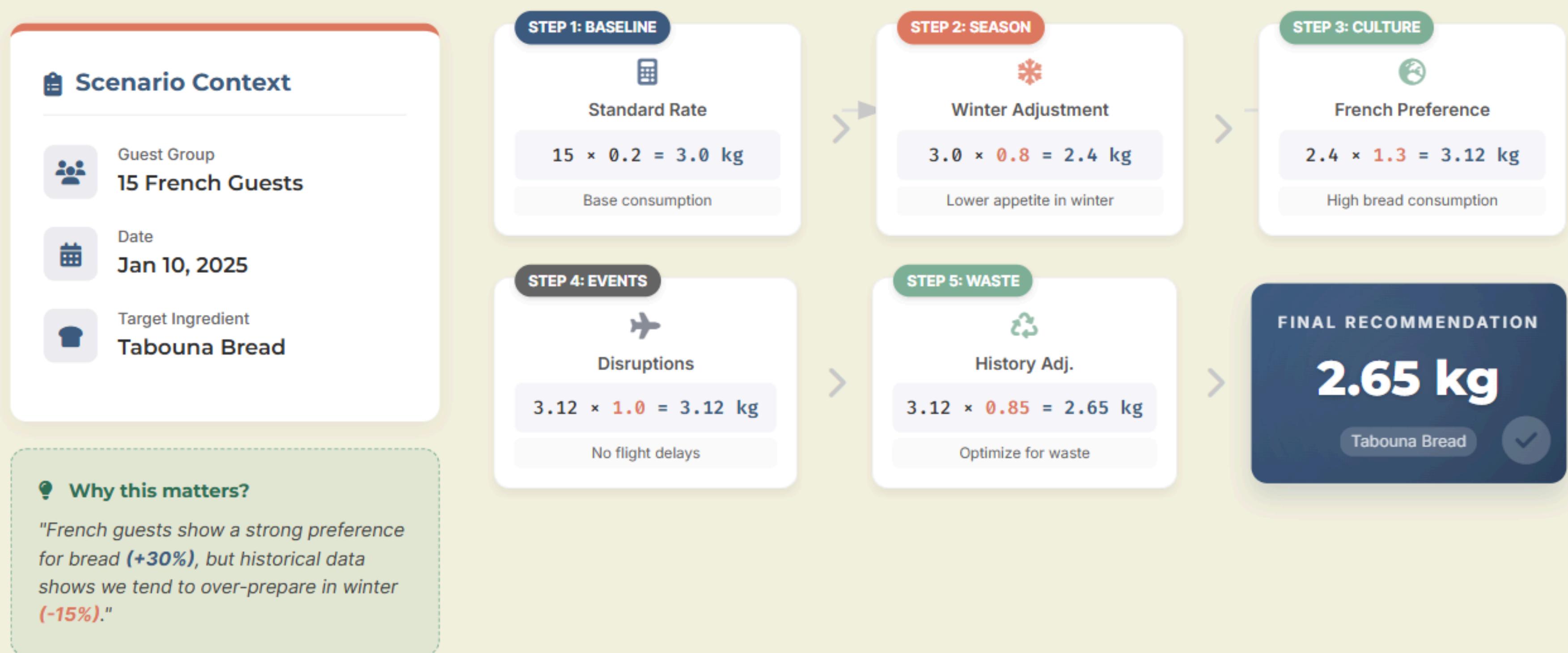
Dynamic reduction based on historical waste patterns.

Range: 0.85 – 1.0

Unlike ~~black-box ML~~, every factor in this formula is transparent, adjustable, and explainable.

Example Calculation

Scenario Context

Guest Group
15 French Guests

Date
Jan 10, 2025

Target Ingredient
Tabouna Bread

Why this matters?

"French guests show a strong preference for bread (+30%), but historical data shows we tend to over-prepare in winter (-15%)."

STEP 1: BASELINE

Standard Rate

$15 \times 0.2 = 3.0$ kg

Base consumption

STEP 2: SEASON

Winter Adjustment

$3.0 \times 0.8 = 2.4$ kg

Lower appetite in winter

STEP 3: CULTURE

French Preference

$2.4 \times 1.3 = 3.12$ kg

High bread consumption

STEP 4: EVENTS

Disruptions

$3.12 \times 1.0 = 3.12$ kg

No flight delays

STEP 5: WASTE

History Adj.

$3.12 \times 0.85 = 2.65$ kg

Optimize for waste

**FINAL RECOMMENDATION**

2.65 kg

Tabouna Bread

Database Schema: 9 Core Models

Nationality 🌐
PK	id
name	
bread_pref	

Guest 👤
PK	id
name	
FK	nationality_id

Disruption ⚡
PK	id
type	
severity	
FK	reserv_id

Reservation 📅
PK	id
date	
FK	guest_id
guest_count	

WasteLog 🗑
PK	id
amount_kg	
reason	
FK	reserv_id

Dish 🍴
PK	id
name	
category	
prep_time	

Ingredient 🥕
PK	id
name	
base_rate	
FK	dish_id

Supplier 🚚
PK	id
name	
distance_km	

Season ⚙
PK	id
name	
factor_score	

SCHEMA OVERVIEW

9
Core Models

12
Relationships

50+
Data Fields

IMPLEMENTATION
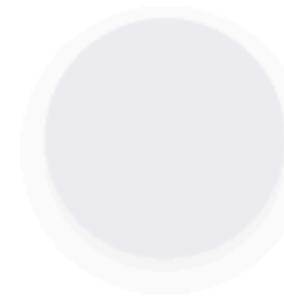
Complex many-to-many and foreign key relationships handled via SQLAlchemy ORM.

`SQLAlchemy` `SQLite/PostgreSQL`

`Pydantic`
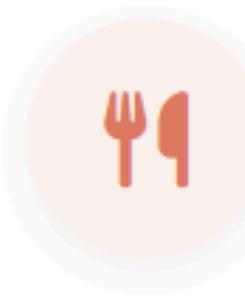
# Three Intelligence Engines

Forecast Engine
DEMAND PREDICTION

- **Demand Prediction:** Multi-factor algorithm utilizing historical and external data.
- **Transparency:** Fully explainable logic vs. black-box machine learning.
- **Factor Analysis:** Breaks down impact of season, culture, and events.
- **Feedback Loop:** Continuously learns from waste logs and corrections.

Cultural Engine
MENU INTELLIGENCE

- **Menu Generation:** Dynamically creates menus based on guest profiles.
- **Seasonal Matching:** Aligns ingredients with Tunisian harvest calendars.
- **Heritage Preservation:** Prioritizes traditional recipes and local terroir.
- **Cultural Notes:** Generates context for staff about guest preferences.

Waste Analyzer
IMPACT ANALYTICS

- **Pattern Detection:** Identifies consistent sources of over-preparation.
- **Trend Analysis:** Tracks waste reduction progress over time.
- **Cost Calculation:** Converts kilogram waste into financial loss (TND).
- **Recommendations:** Suggests actionable changes to prep quantities.

Service Layer Architecture

`services/intelligence/*.py`

7 Advanced Analytics Endpoints

Procurement Optimizer
`POST /opt/procure`

✓ Multi-day smart shopping lists

✓ Bulk discount calculations

✓ Carbon footprint tracking

Nationality Comparison
`GET /ana/nation`

✓ Cross-nationality preference analysis

✓ Cost-per-guest comparisons

✓ Consumption pattern detection

Waste Impact Simulator
`POST /sim/waste`

✓ Forecasting strategy testing

✓ ROI & savings projections

✓ "What-if" scenario modeling

Kitchen Dashboard
`GET /dash/kitchen`

✓ Real-time prep requirements

✓ Critical stock alerts & warnings

✓ Live service monitoring

Seasonal Optimizer
`GET /opt/season`

✓ Menu sustainability scoring

✓ Ingredient availability checks

✓ Terroir-based suggestions

Cost-Benefit Analysis
`POST /ana/finance`

✓ Financial impact assessment

✓ Break-even calculation

✓ Waste cost tracking

Cultural Insights
`GET /data/culture`

✓ Guest preference matrices

✓ Cuisine compatibility analysis

✓ Heritage food education
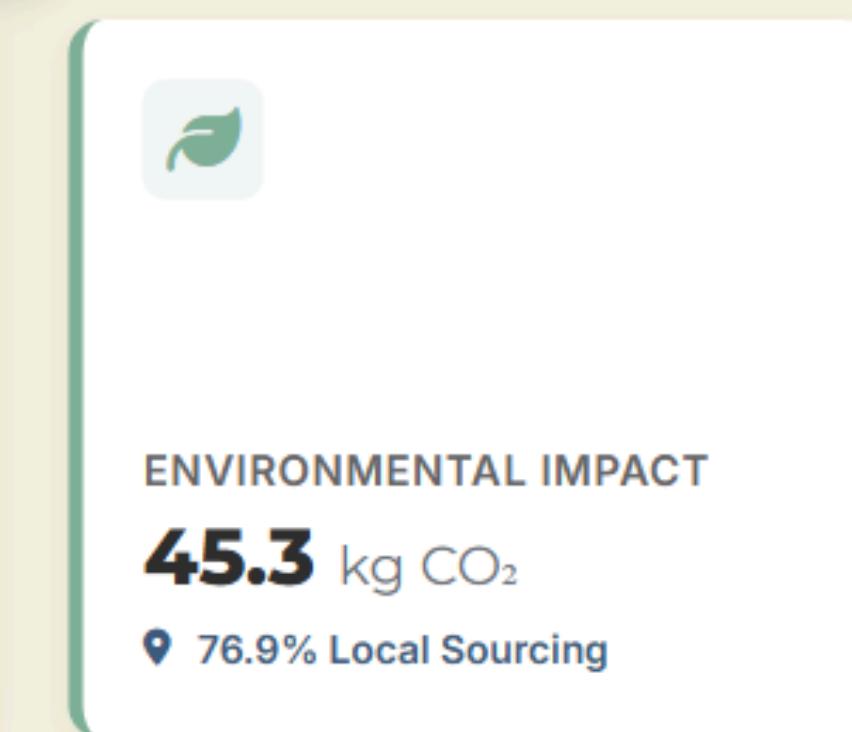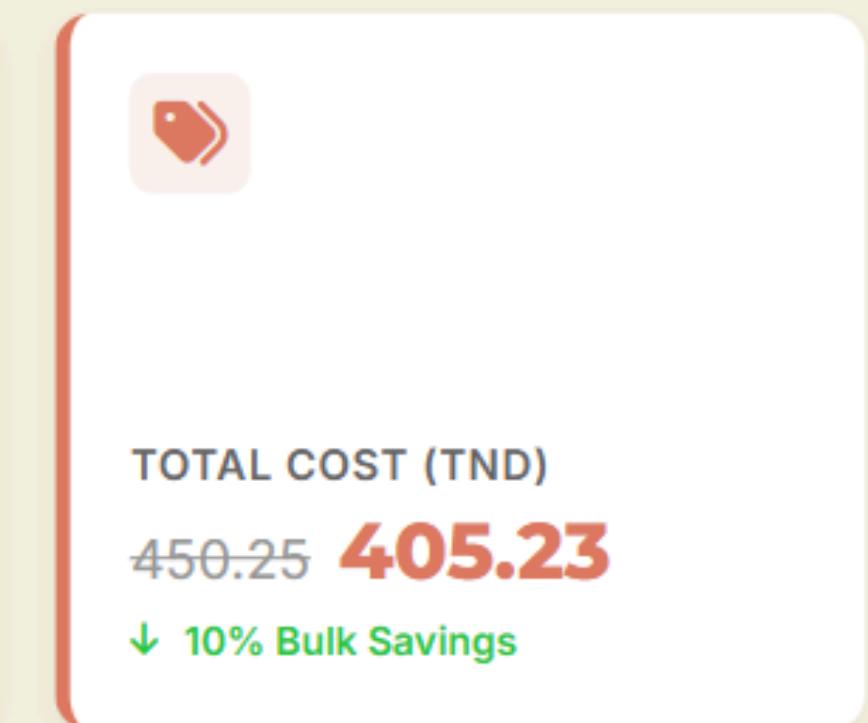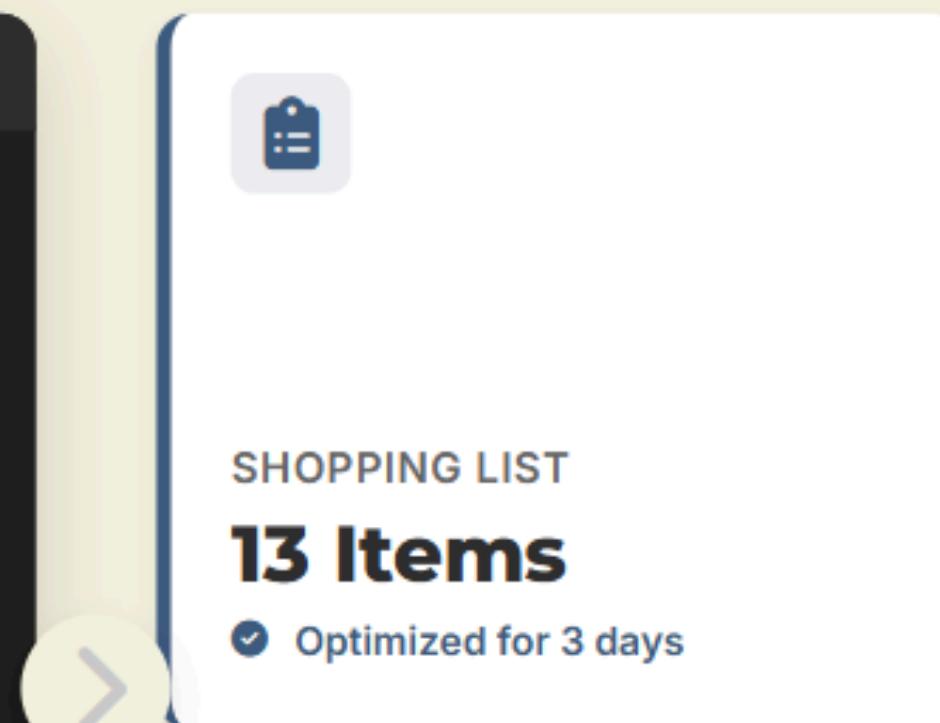
Procurement Optimizer Demo

POST /intelligence/procure

Optimization Results

```json
{
"guests": [
{
"nationality": "FRA",
    "count": 10,
    "dates": [
"2025-01-13",
        "2025-01-14"
]
},
    {
"nationality": "DEU",
    "count": 5,
    "dates": [
"2025-01-15"
]
}
],
  "optimize_for": "cost_waste"
}
```

SHOPPING LIST

13 Items

✅ Optimized for 3 days

TOTAL COST (TND)

~~450.25~~ **405.23**

↓ 10% Bulk Savings

ENVIRONMENTAL IMPACT

45.3 kg CO$_2$

📍 76.9% Local Sourcing

HIGH WASTE RISK

Bread

⌖ Auto-reduced by 15%

Cultural Intelligence in Action

🀫 Ingredient Demand by Nationality

Ingredient	FRA FRENCH	DEU GERMAN	TUN TUNISIAN
Tabouna Daily Bread	2.65 kg	**HIGHEST** 3.06 kg	2.86 kg
Yogurt Dairy/Breakfast	**HIGHEST** 1.44 kg	1.32 kg	0.96 kg
Harissa Spice Paste	0.06 kg	0.07 kg	**HIGHEST** 0.18 kg

"Same occupancy, dramatically different needs"
Static menus generate waste; Dynamic menus generate value.

💡 Key Cultural Insights

Bread Consumption
German guests require **~23% more bread** than French guests, preferring heavier, grain-based varieties.

Spice Tolerance
Tunisians consume **3x more harissa** than Europeans. European menus require significantly milder options.

Dairy Preferences
French guests prefer **~50% more dairy** (yogurt/cheese) at breakfast compared to local Tunisian standards.

ⓘ *Data derived from 12-month analysis of consumption patterns in 5 pilot guest houses.*
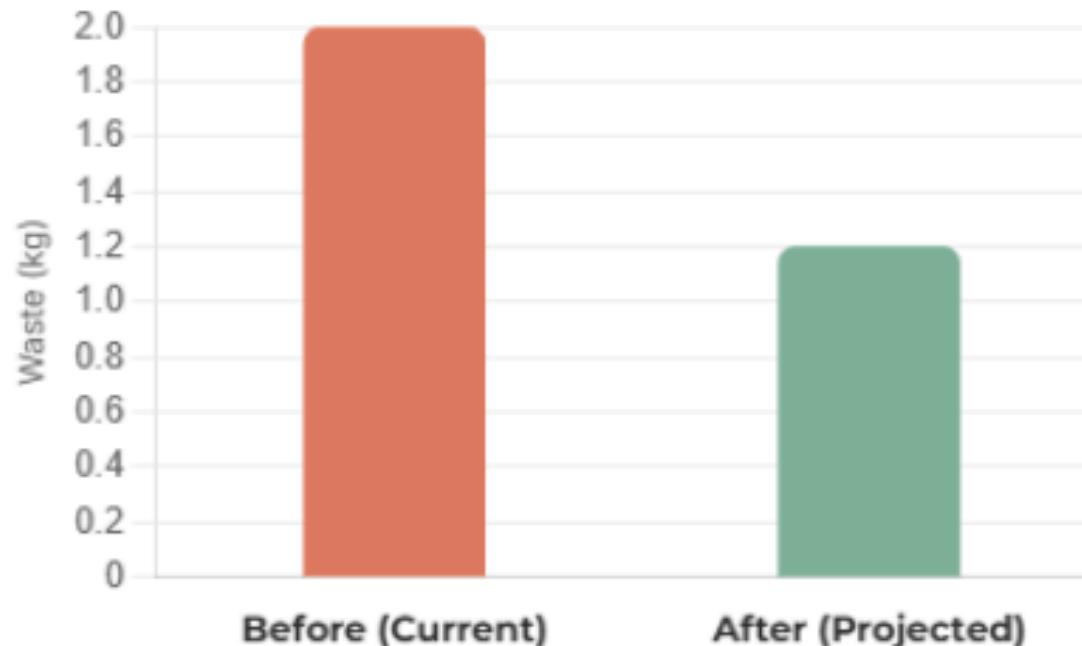
Measurable Impact & Conclusion

Current State ⚠

🗑 **2.0 kg Waste / 30 Days**
Baseline measurement (Pilot)

≔ **Top Wasted Items**
Tabouna (1.5kg), Eggs (0.5kg)

🔍 **Root Cause**
Unanticipated flight delays & static menus

PROJECTED WASTE REDUCTION

Waste (kg) — y-axis: 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

| Before (Current): 2.0 | After (Projected): 1.2 |

Projected Outcome ✓

✏ **System Actions**
Flight tracking alerts • Weather adjustments

↓ **Optimizations**
Reduced bread prep by 20%

🍃 **Result**
Waste reduced to 1.2 kg (40% drop)

ANNUAL SAVINGS
1,458 TND
~121.5 TND / month

WASTE REDUCTION
40.2%
From baseline

SUSTAINABILITY
76.9%
Local Sourcing Rate

ROI TIMEFRAME
< 3 Mo
Break-even point

❝ Technology should enhance cultural traditions, not replace them. The Terroir Brain API proves that intelligent systems can preserve heritage while achieving modern sustainability goals.

Thank You

🐙 github.com/Elaa2002/Terroir_BRAIN
✉ ella.marco.tn@gmail.com
◆ Google AI Studio Front-end