

# UNICEF Nutrition Allocation Decision Support with Databricks and Gurobi

Model Formulation and POC Design

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unicef 

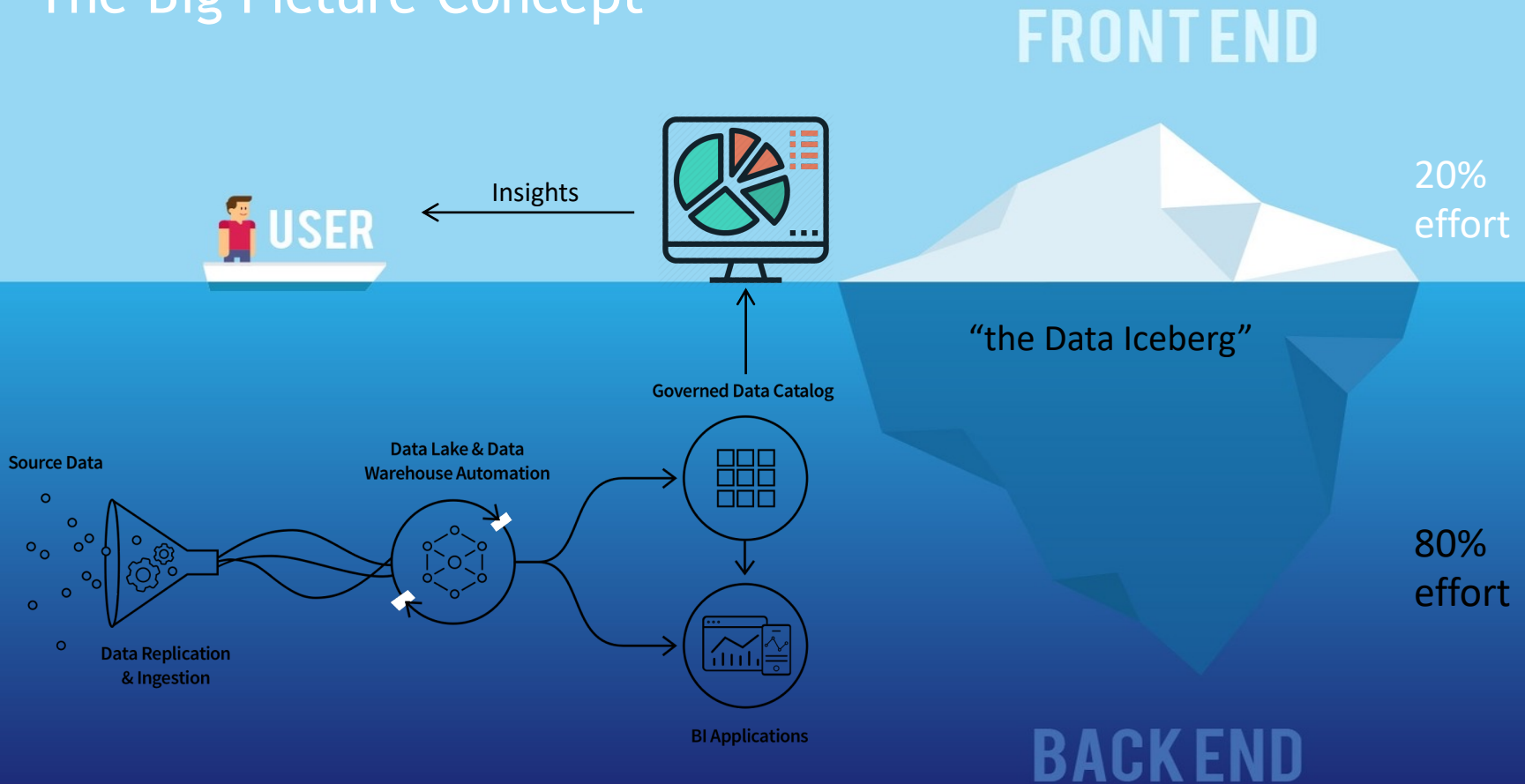
for every child



# Agenda

- Background
- Problem description
- Model formulation
- PoC outputs, process and other IT systems
- Demo
- Next steps
- Q&A

# The Big Picture Concept





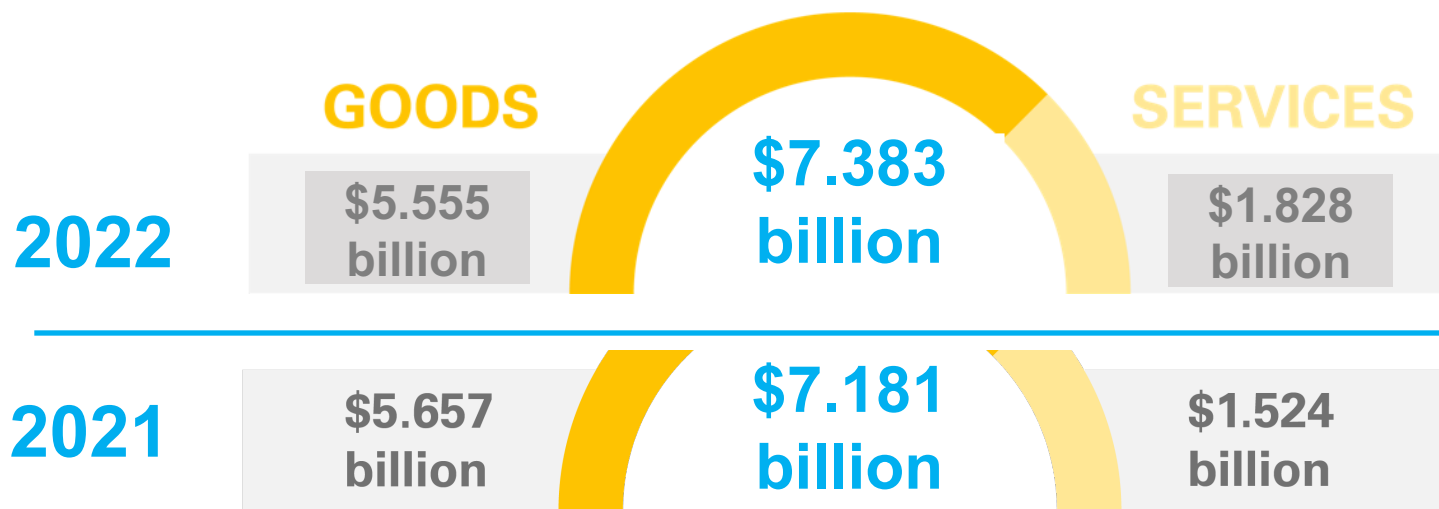
<b>1</b> NO POVERTY 	<b>2</b> NO HUNGER 	<b>3</b> GOOD HEALTH 	<b>4</b> QUALITY EDUCATION 	<b>5</b> GENDER EQUALITY 	<b>6</b> CLEAN WATER AND SANITATION 
<b>7</b> RENEWABLE ENERGY 	<b>8</b> GOOD JOBS AND ECONOMIC GROWTH 	<b>9</b> INNOVATION AND INFRASTRUCTURE 	<b>10</b> REDUCED INEQUALITIES 	<b>11</b> SUSTAINABLE CITIES AND COMMUNITIES 	<b>12</b> RESPONSIBLE CONSUMPTION 
<b>13</b> CLIMATE ACTION 	<b>14</b> LIFE BELOW WATER 	<b>15</b> LIFE ON LAND 	<b>16</b> PEACE AND JUSTICE 	<b>17</b> PARTNERSHIPS FOR THE GOALS 	
					<b>THE GLOBAL GOALS</b> For Sustainable Development

# SUPPLY DIVISION: CRITICAL FUNCTIONS

- Supports results for children with an **effective, efficient supply operation**
- Helps meet UNICEF Core Commitments for Children in emergencies by providing **rapid response to emergency supply and logistics** needs
- Contributes to **influencing markets** to ensure sustainable access to essentials supplies for children
- Serves as a **centre of expertise** and knowledge on essential supplies for children and supply chains, while **building capacities of national governments**
- Provides **procurement services** to governments and development partners on strategic and essential supplies
- Establishes **policies for supply chain** activities
- Uses **product innovation** to increase results and decrease costs



# UNICEF PROCUREMENT VALUE



- In 2022 UNICEF procured **\$7.383 billion worth of supplies and services** – representing a 3 per cent increase from 2021 levels and a 93 per cent increase from 2019 (pre-pandemic) levels.
- The 2022 levels were driven by the response to new and ongoing emergencies, the Food Insecurity Crisis, and continued demand for construction services

# Nutrition Shipped in 2022



**\$392.4 million**

## NUTRITION SUPPLIES

Nutrition supplies delivered in 2022 represented a 90 per cent increase from 2021, primarily in ready-to-use therapeutic food (RUTF).

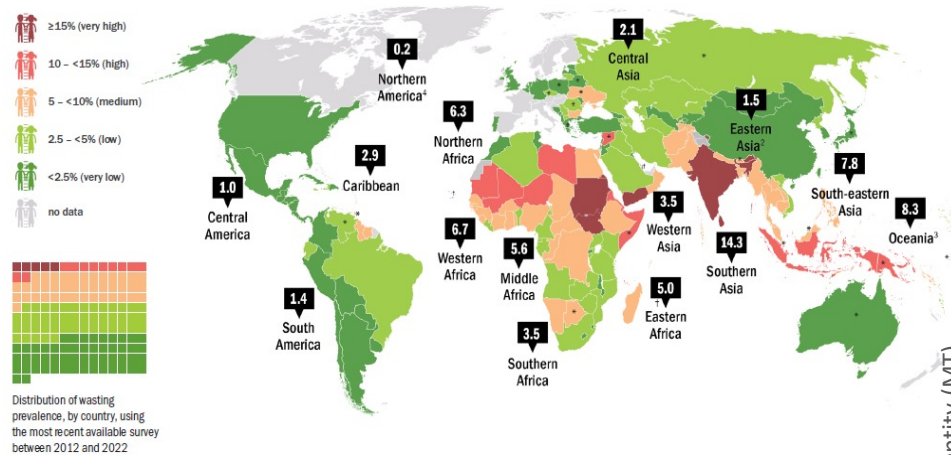
UNICEF delivered

- **68,702 metric tons** of RUTF to 64 countries.
- **920 metric tons** of therapeutic milk to 60 countries.
- **18.6 million** mid-upper arm circumference tapes for children in 54 countries.
- **475.9 million** vitamin A capsules to 71 countries.
- **101.1 million** deworming tablets to 49 countries.
- **612.7 million** sachets of multiple micronutrient powder to 42 countries.
- **482.0 million** iron folic acid tablets to 40 countries.

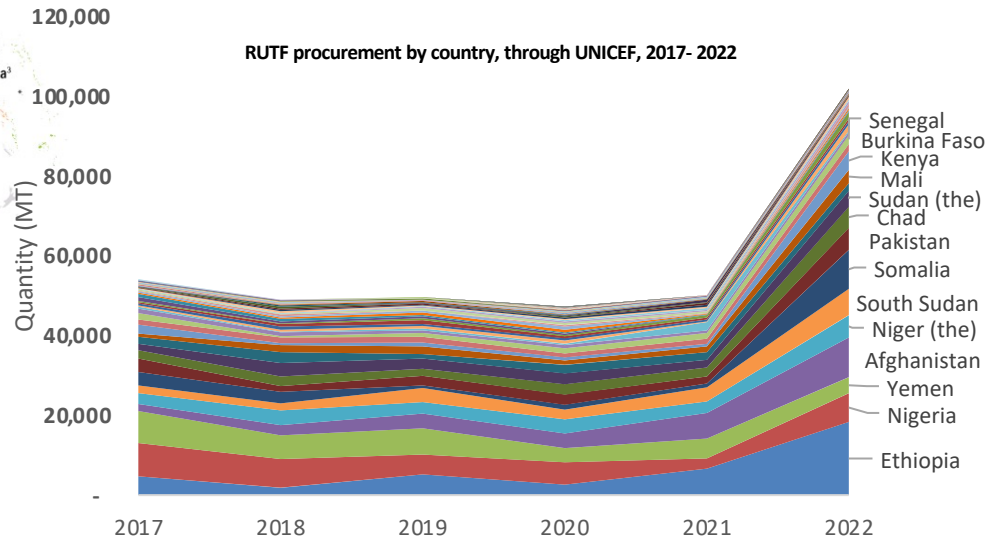


# Global prevalence of Wasting

Percentage of children under 5 affected by wasting, by country and United Nations sub-region, 2022

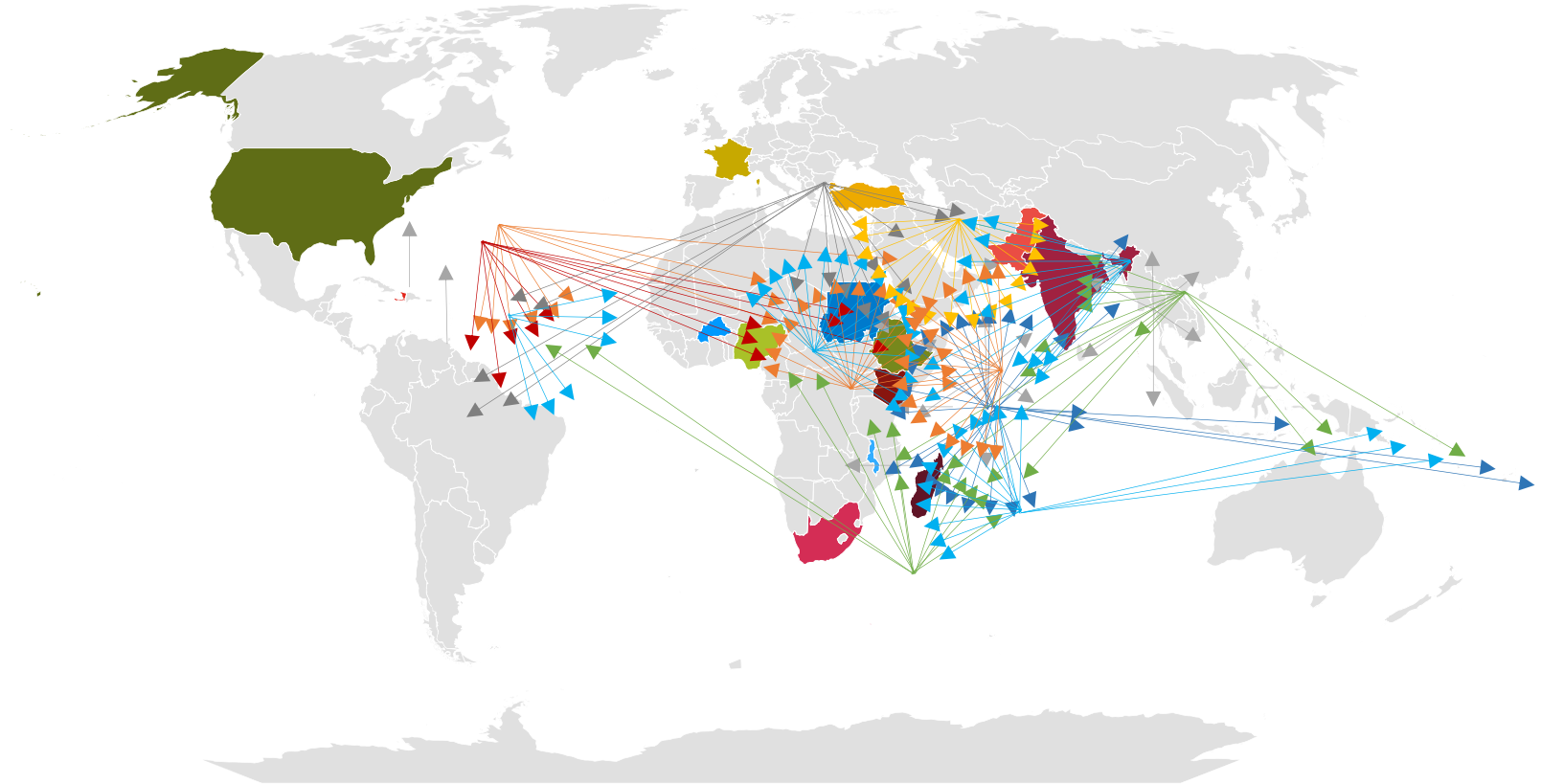


- Global RUTF demand has increased exponentially over the past two decades with 80% of demand driven by top 13 countries
- Although the burden of wasting is highest in Asia, demand in Africa is higher than Asia
- India has not adopted RUTF at national level and that accounts for a large portion of untreated wasting globally





# Overview of supply channels pre-optimization



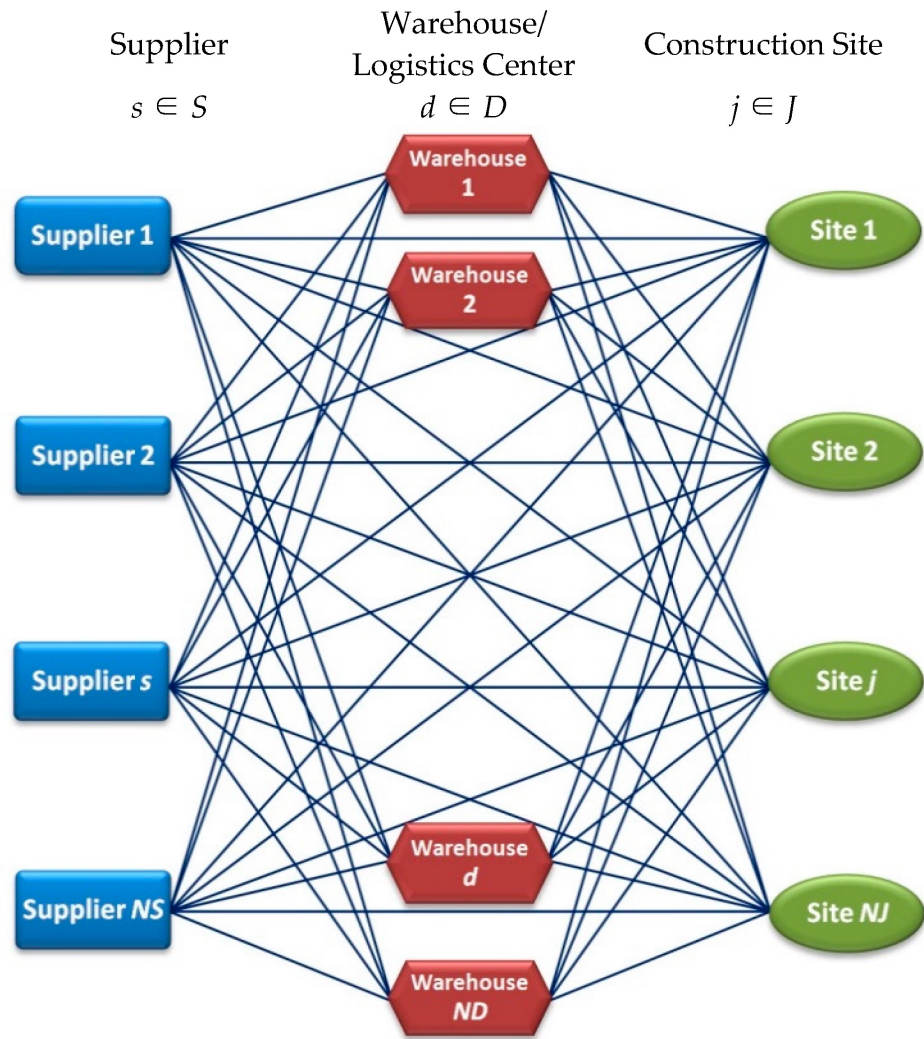
# Problem Description

UNICEF Supply Division was looking to enhance our allocation capabilities with the RUTF product. Regular demand for steady state operations were achievable with current methods but were challenged to meet demand in the case of an emergency or other sudden reallocations.

There was also an opportunity to improve the day-to-day operations, not just the reaction in emergencies, by leveraging a data platform for our needs.

# Model Formulation

- At its core, this challenge involves **resource allocation**
- Specifically, this is a version of the classic [Transportation Problem](#) under the larger category of [mixed-integer linear programming](#)
- Solving such a problem requires identifying:
  - An **objective function**: a quantity to minimize or maximize, e.g. cost or time
  - A set of **decision variables**: essentially, the knobs that can be turned, e.g. purchase orders
  - A set of **constraints**: limits on the values of decision variables (or functions of variables), such as non-negativity, inventory limits, contract fulfillment, etc.



*\*Generic example*

# Understanding the problem

- How much each country needs per month (demand/forecast)
- What suppliers can produce / have on hand (capacity & availability)
- How long will it take to deliver the needed product from the supplier to the demand location (shipment time)
- Which suppliers can provide the product to each location (based on contract agreements / constraints)

# Model Formulation: Objective Functions

- Meet funded country demands, optionally weighted to reflect priorities or UNICEF supply chain insights about needs (i.e. penalize unmet sales orders)
- **Minimize shipping time (by choosing the most optimal supplier/country combination)**

# Model Formulation: Decision Variables

- POs by supplier, country and month
- Shipments by supplier, country and month (allows for possibility of re-allocation)

# Model Formulation: Constraints

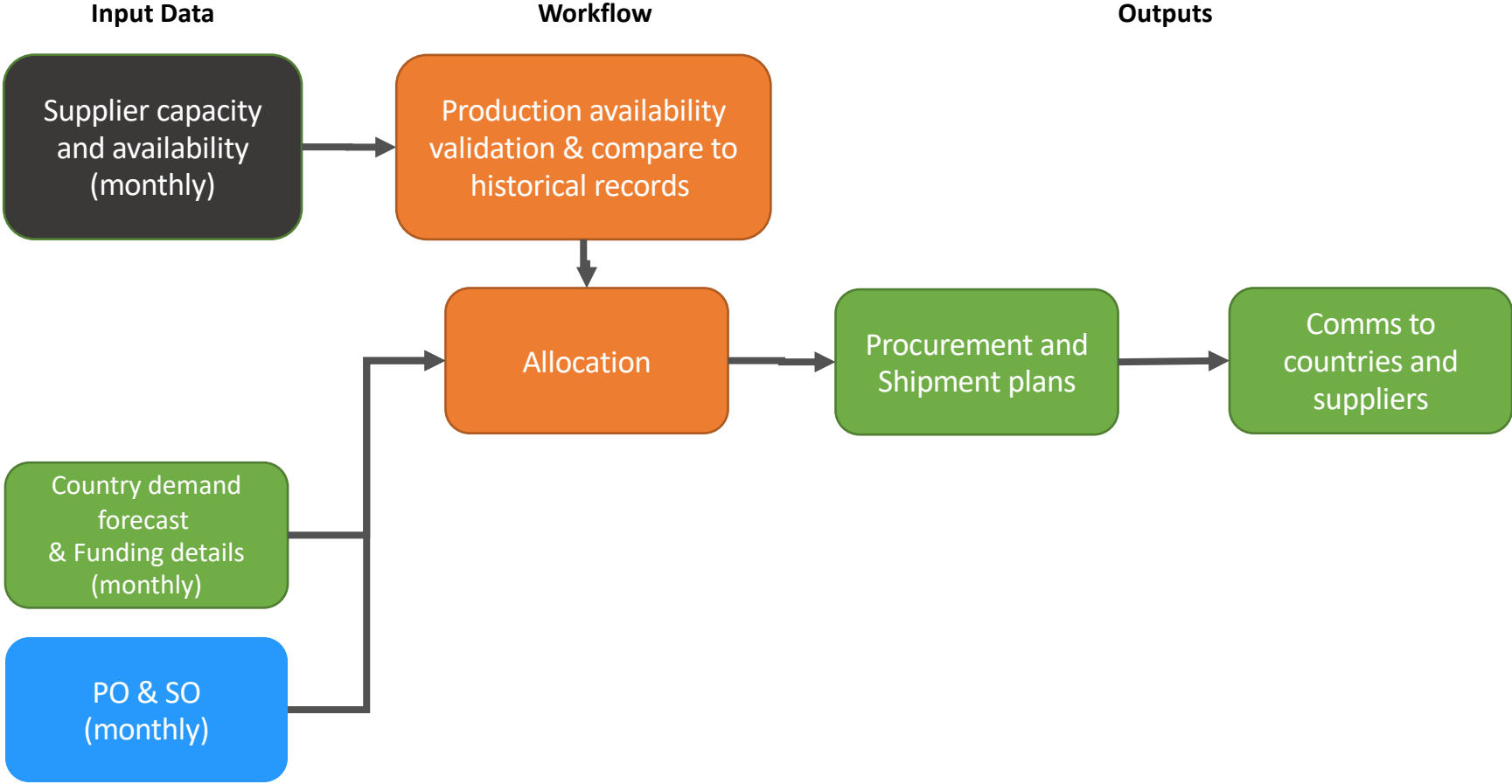
- POs don't exceed supplier availability (on hand supply)
- (Funded) country demands are met (either on-time, or eventually - see Objective 3)
- Shipments by supplier don't exceed on-hand inventory plus POs
- Shipment lead time to the country
- Supplier inventory by month = [previous inventory] + [new POs] - [shipments]
- Some POs cannot be modified, i.e. contractual obligations



# Model Formulation: Input Data

- Country demand forecasts, by country and month
- Supplier availability, by supplier and month
- PO details: existing commitments by supplier and month
- Lead time details:
  - Supplier-specific lead time, independent of order quantity or shipping location
  - Supplier-country combination shipping lead time

# High Level Process (before and after allocations)



# Supplier Inputs

Collaborative Procurement Portal unicef BK Bhushan Kulkarni Nut. Supplier

Year: 2023 Download Template Import Export To Excel

Action	Month	RUTFCT	RUTFCT Prev	RUTFMT	RUSFCT	RUSFCT Prev	RUSFMT	RUSFMT Prev	TotalMT	V	S
	January	18,000	15,000 ⓘ		5,600	5,200 ⓘ	84	78 ⓘ	332.4		
	February										
	March										
	April										
	May										
	June										
	July										
	August										
	September										
	October										

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[Feedback](#)

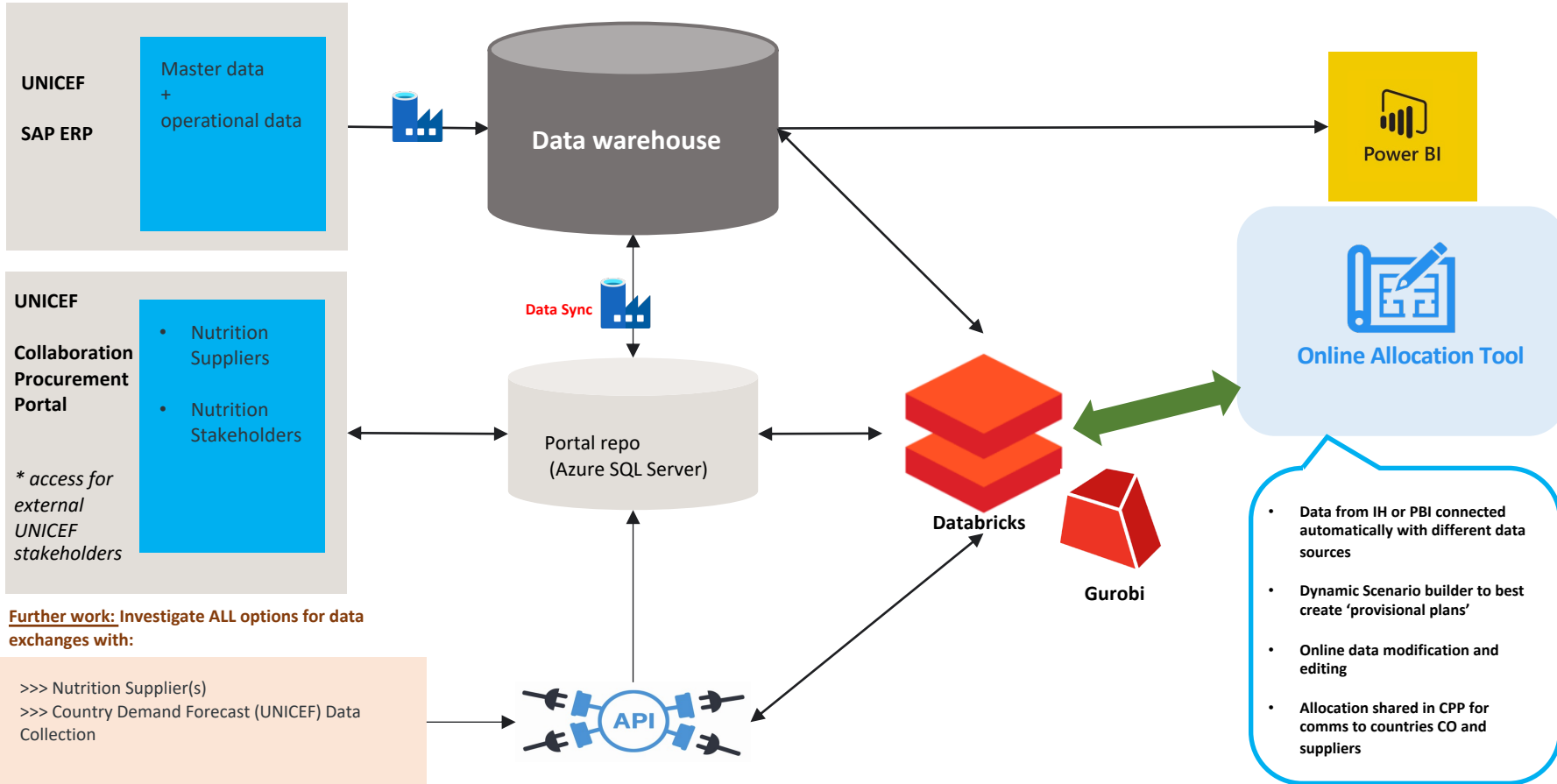
# Data => Nutrition Allocation

Data sources

Ingest/Model

Prep/Run

Serve and display



# PoC Outputs (Live Demo)

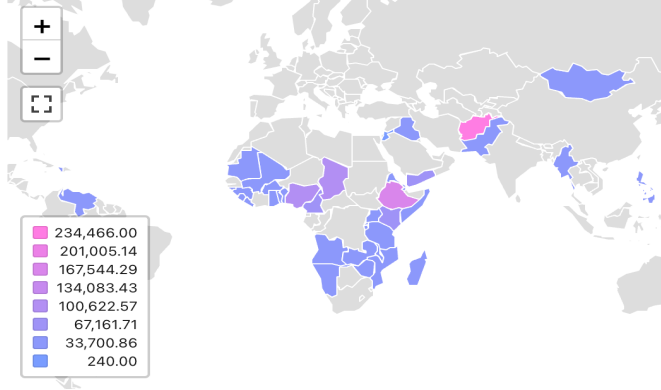
Forecasted country demand

Country_Name	ISO_Code	Delivery_Date	Quantity_Carto
Nigeria	NG	2023-10-01	390
Rwanda	RW	2023-11-01	75
Iraq	IQ	2023-11-01	3
Lao,Peo.Dem.Rep	LA	2023-11-01	26
Namibia	NA	2023-11-01	41
Burundi	BI	2023-11-01	20
Ghana	GH	2023-11-01	84
Burkina Faso	BF	2023-11-01	8

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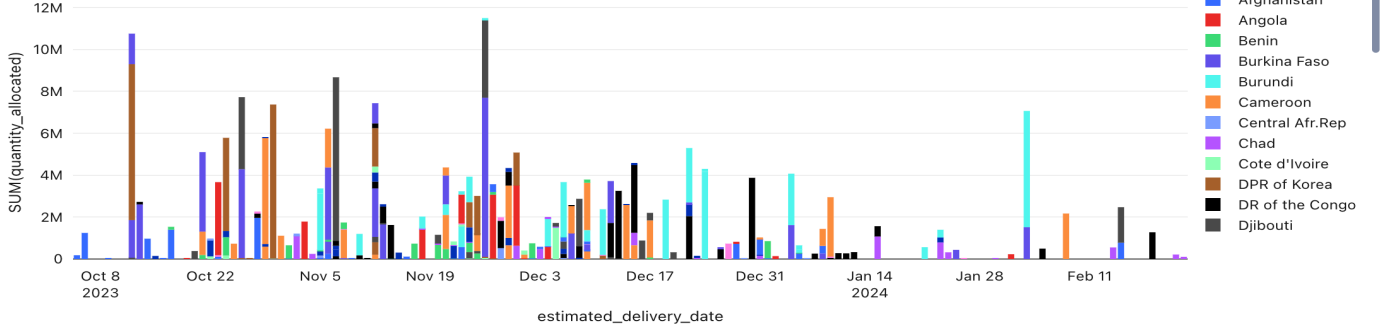
just now

Map - All Demands




just now

Allocation Results - Supply Timeline (estimated)




just now

# Some interesting facts

- Technology: Databricks, Python, Gurobi Solver
  - The combination of suppliers and demand locations resulted in over 65,000 distinct routes.
  - Total development time for the PoC was ~80 hours
  - **Through tuning and enhancement, we reduced time from around 2 hours to less than a minute to run full model using Gurobi Solver**
  - This was just one product, ultimately UNICEF manages over 10,000 products across the globe, and this could be applied to others.
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# Next steps

Develop the next iteration of the PoC

- Further code refinement
  - Compare execution strategies (real-time vs pre-aggregated data)
  - Accommodate more business requirements
  - Data validation/testing and tuning
  - Evaluate use in other products
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Thank You!  
Q&A