

# MAPPING ECOSYSTEM SERVICE FLOWS IN SENEGAL: Sardinella protein flows from small-scale fisheries



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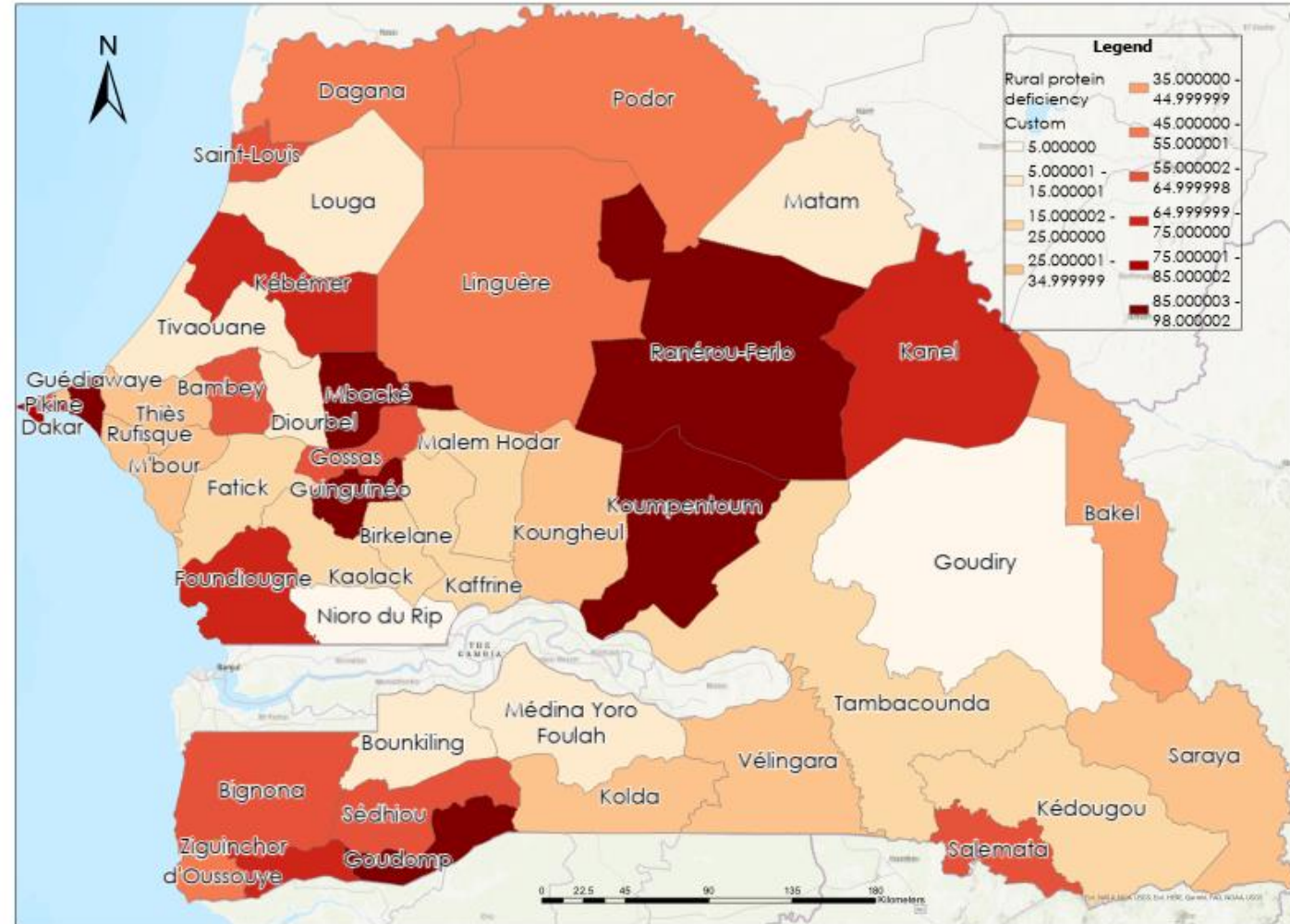
Course: **Global Challenges And Local Actions**

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# INTRODUCTION

- Senegal has an extensive maritime and coastal zone extended to 221,818 km<sup>2</sup> **larger than the mainland** (196,227 km<sup>2</sup>)
- Coastal area provides a large number of marine ecosystem services:
  - **Sea food Provision (350,000 Tons/year)**
  - Employment (600,000 people)
  - Tourism (recreational fishing)
  - Marine Biodiversity
- High **dependency on seafood** proteins for food security and livelihoods.
- **Poor** management in the **distribution** of fish and its products threatens this marine resource and its contribution to food security and nutrition(URT, 2015).

PROTEIN INTAKE DEFICIENCY-RURAL AREAS



Adapted from IFPRI report(2021)

# GLOBAL CHALLENGE, LOCAL ACTION AND SDGs

## Global Challenge:

- Overexploitation of marine Ecosystem Services (ES)
- Food distribution challenges that do not allow everyone to get enough good quality food.
- Large emissions across the supply chain.

## Local Challenge:

- Large seafood dependency as a protein source - inland communities do not have access to this source and are using other products such as millet, rice or peanuts (Marivoet et al., 2021)

## Proposed Local Action:

- Redistribution of fresh and processed seafood.

**2** ZERO  
HUNGER



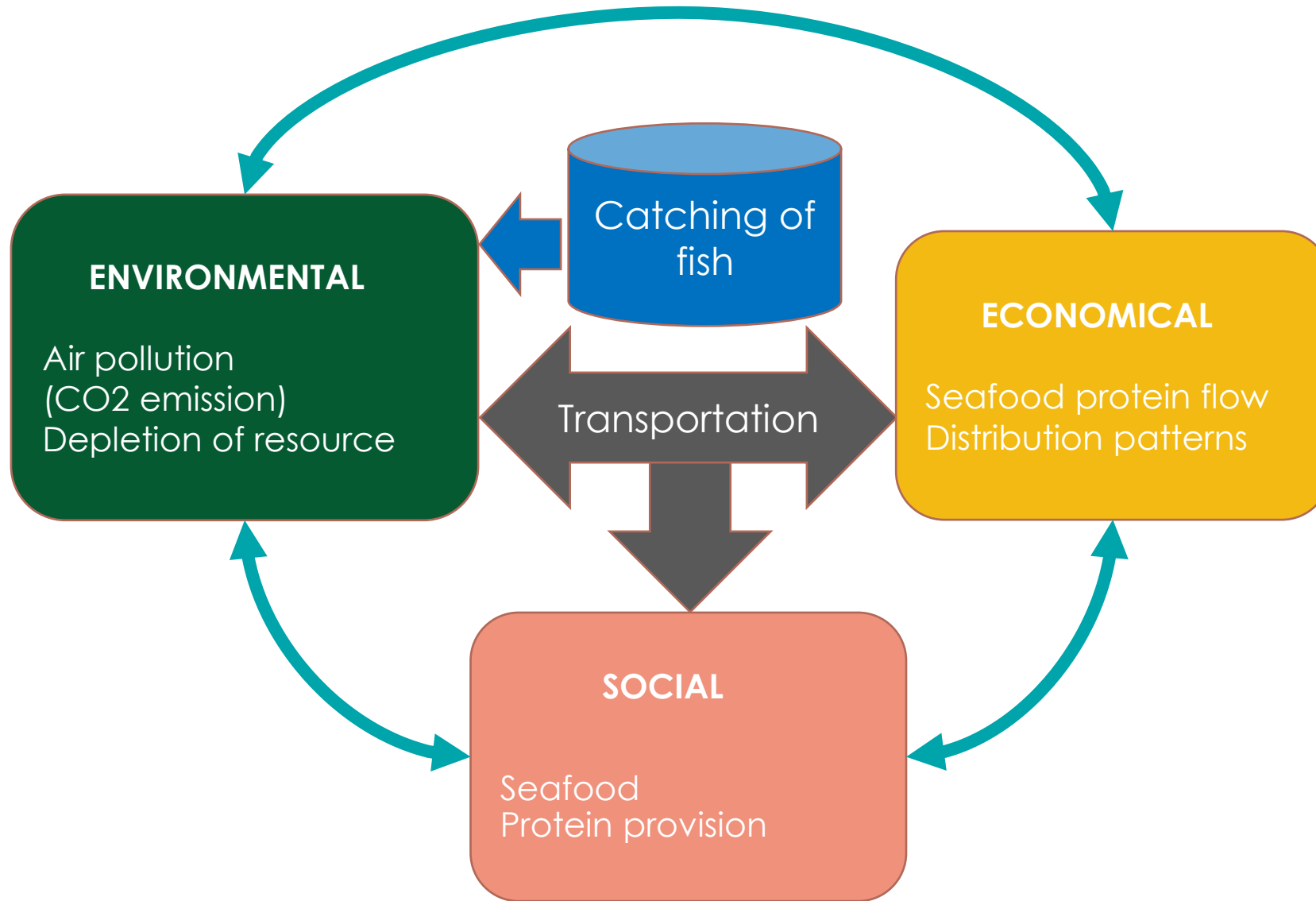
**12** RESPONSIBLE  
CONSUMPTION  
AND PRODUCTION



**13** CLIMATE  
ACTION



# MAIN CONCEPTS- INTERRELATION

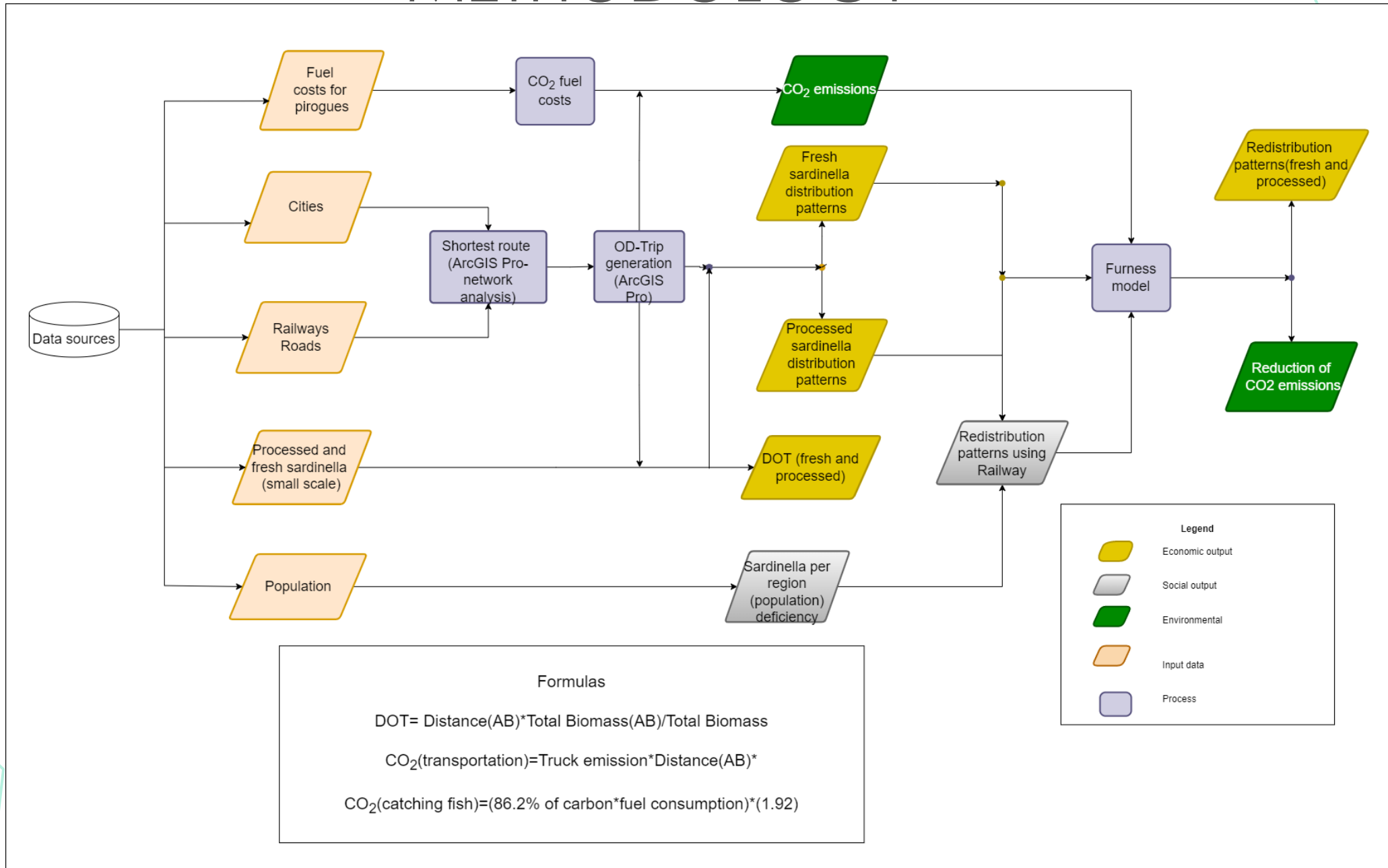


# OBJECTIVES

- To map and assess the marine ES flows (seafood protein), its environmental cost and to propose strategies for sustainable distribution within Senegal.
- To map the flows of seafood protein from the landing sites towards the mainland
- To assess (map and model) the environmental costs (CO<sub>2</sub> emissions) and distance of trade (DOT)
- To propose general strategies for the sustainable distribution of marine ecosystem services.



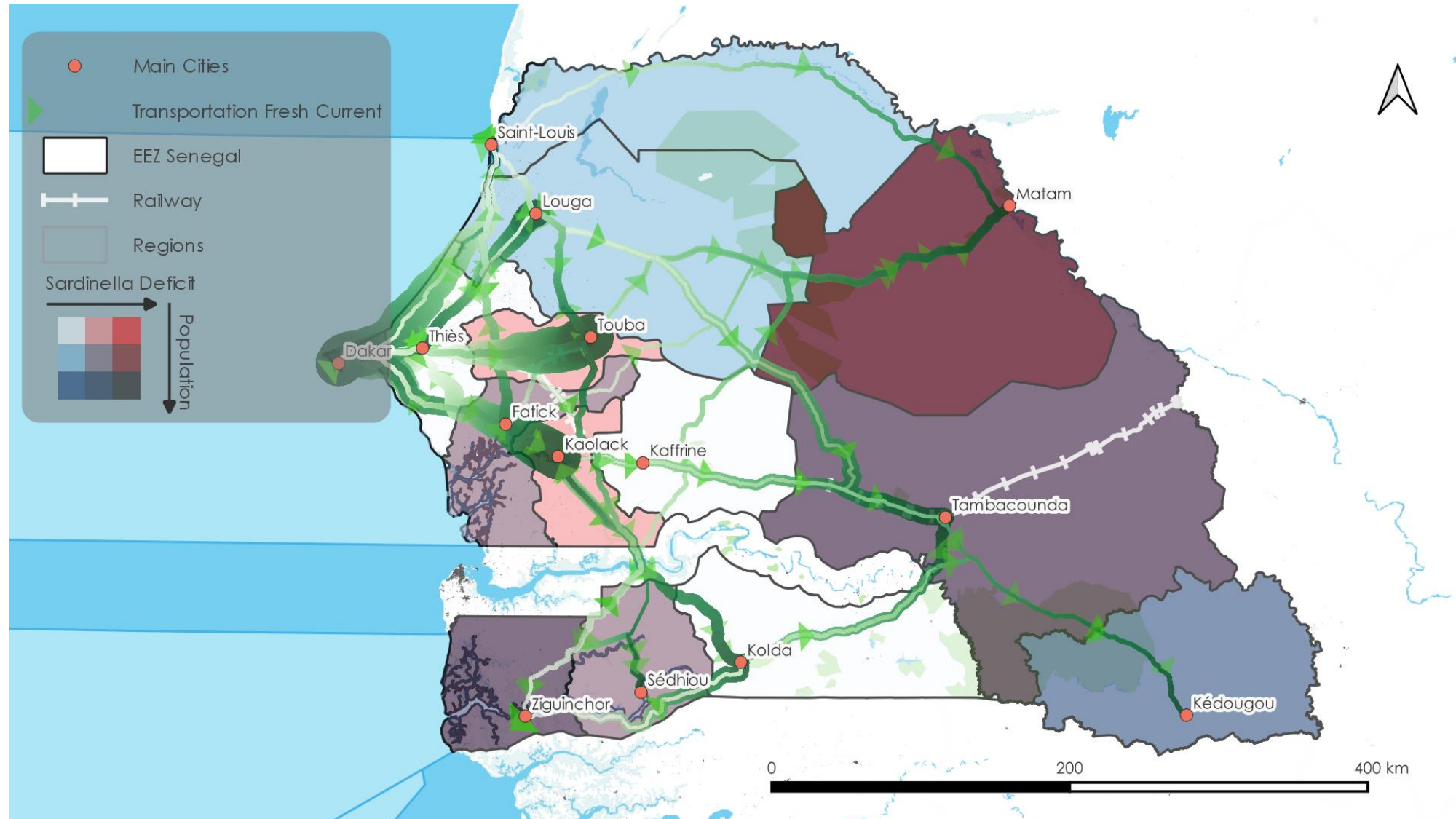
# METHODOLOGY



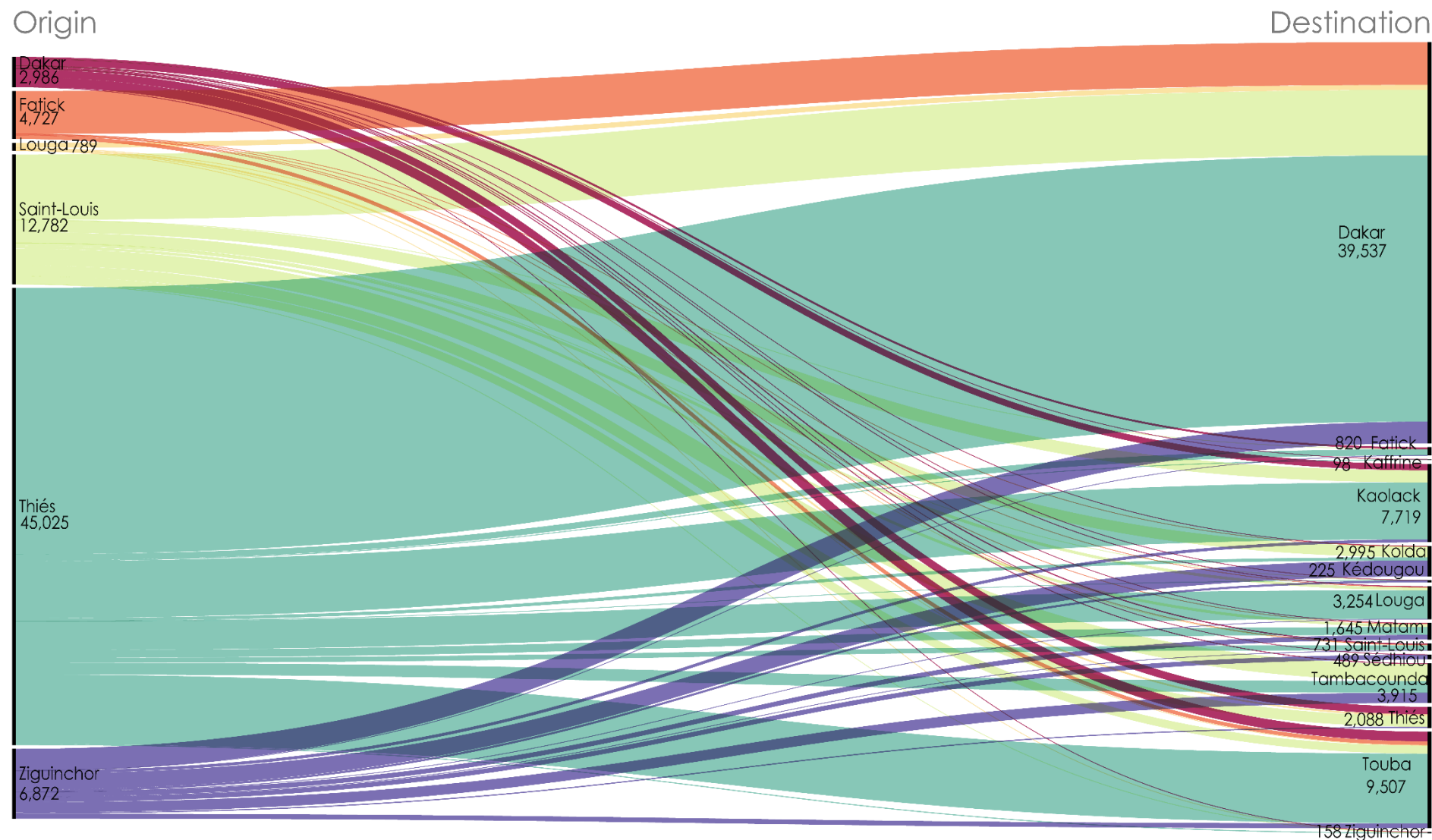


# RESULTS: SARDINELLA DEFICIENCY

- Seafood consumed per person per year is 29kg/per person
- 47% is Sardinella
- This map indicates areas of seafood demand against the existing distribution of fresh seafood. This informs the need for redistribution.



# RESULTS: CURRENT DISTRIBUTION FRESH

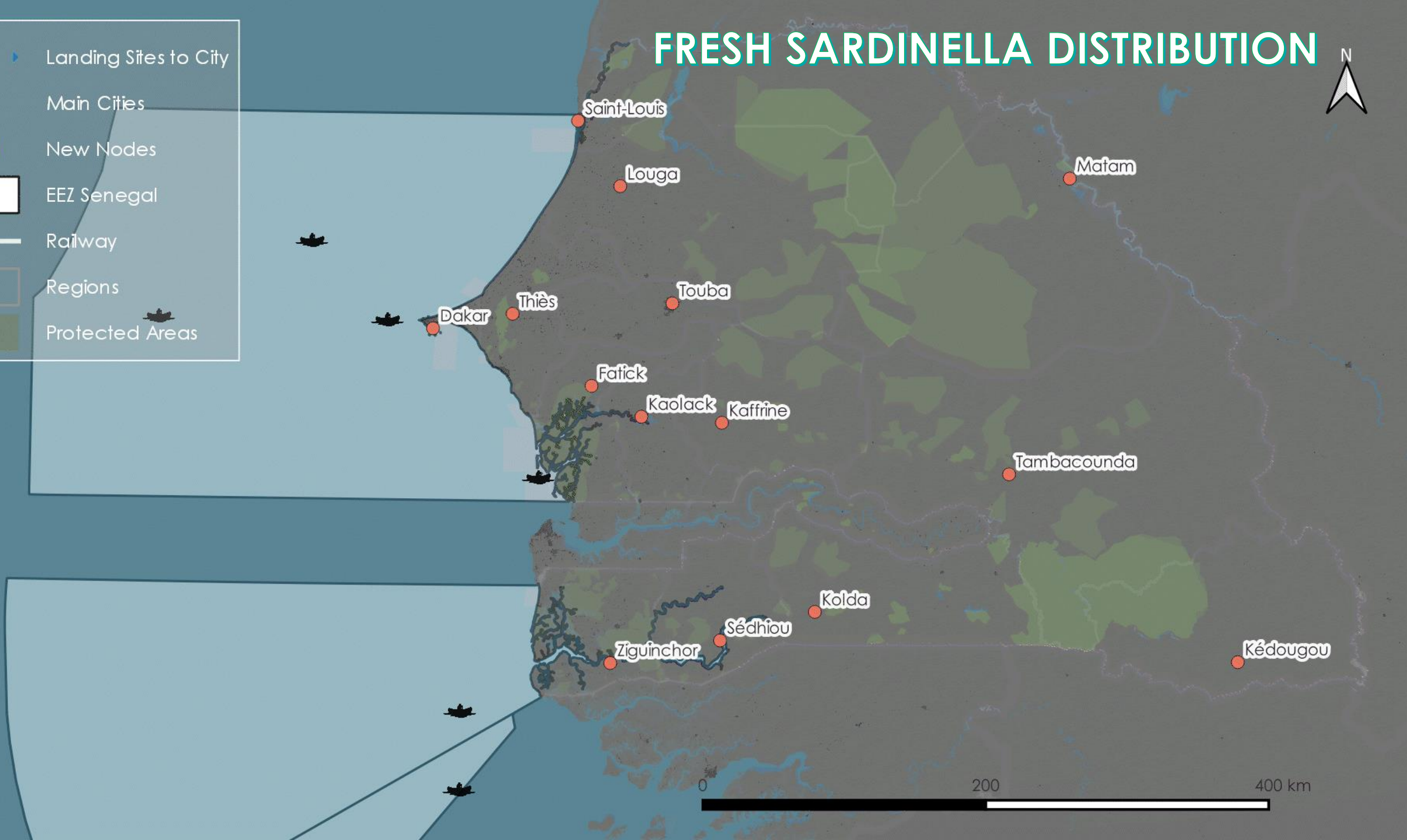


## Fresh Sardinella

Region	Going Out	Going In
Dakar	2,986	39,537
Fatick	4,727	820
Kaffrine	-	98
Kaolack	-	7,719
Kédougou	-	225
Kolda	-	2,995
Louga	789	3,254
Matam	-	1,645
Saint-Louis	12,782	731
Sédhiou	-	489
Tambacounda	-	3,915
Thiès	45,025	2,088
Touba	-	9,507
Ziguinchor	6,872	158
<b>Total</b>	<b>73,181</b>	<b>73,181</b>

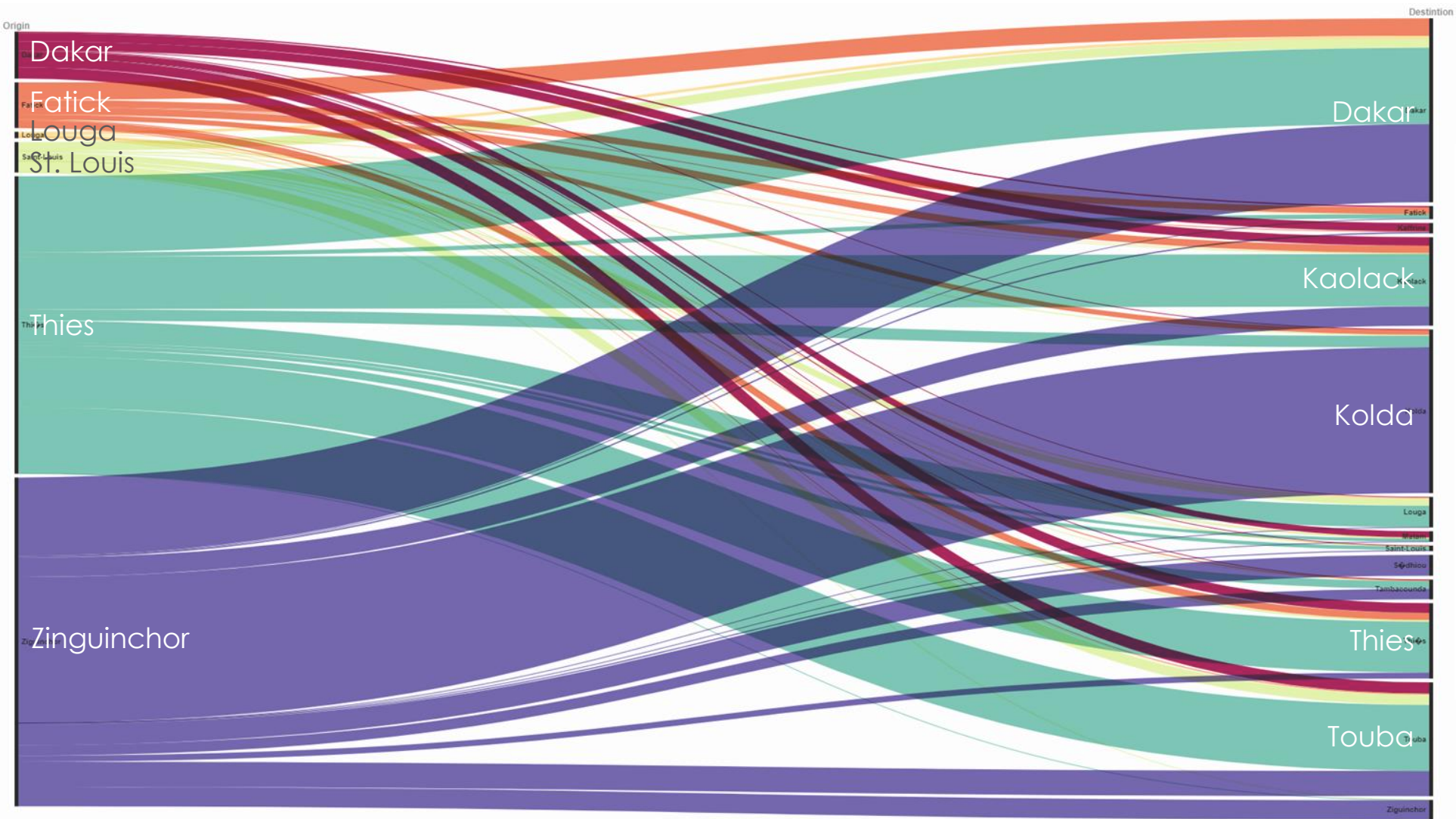


# FRESH SARDINELLA DISTRIBUTION



# RESULTS: CURRENT DISTRIBUTION PROCESSED

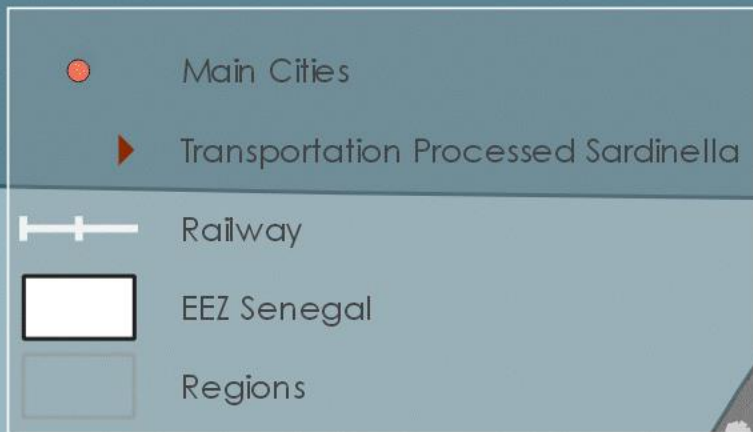
Processed  
Sardinella



Region	Going Out	Going In
Dakar	742	3,047
Fatick	798	217
Kafrine	-	136
Kaolack	-	1,465
Kédougou	-	-
Kolda	-	2,710
Louga	107	506
Matam	-	174
Saint-Louis	504	91
Sédhiou	-	345
Tambacounda	-	328
Thiès	4,925	1,292
Touba	-	1,884
Ziguinchor	5,446	327
Total	12,522	12,522

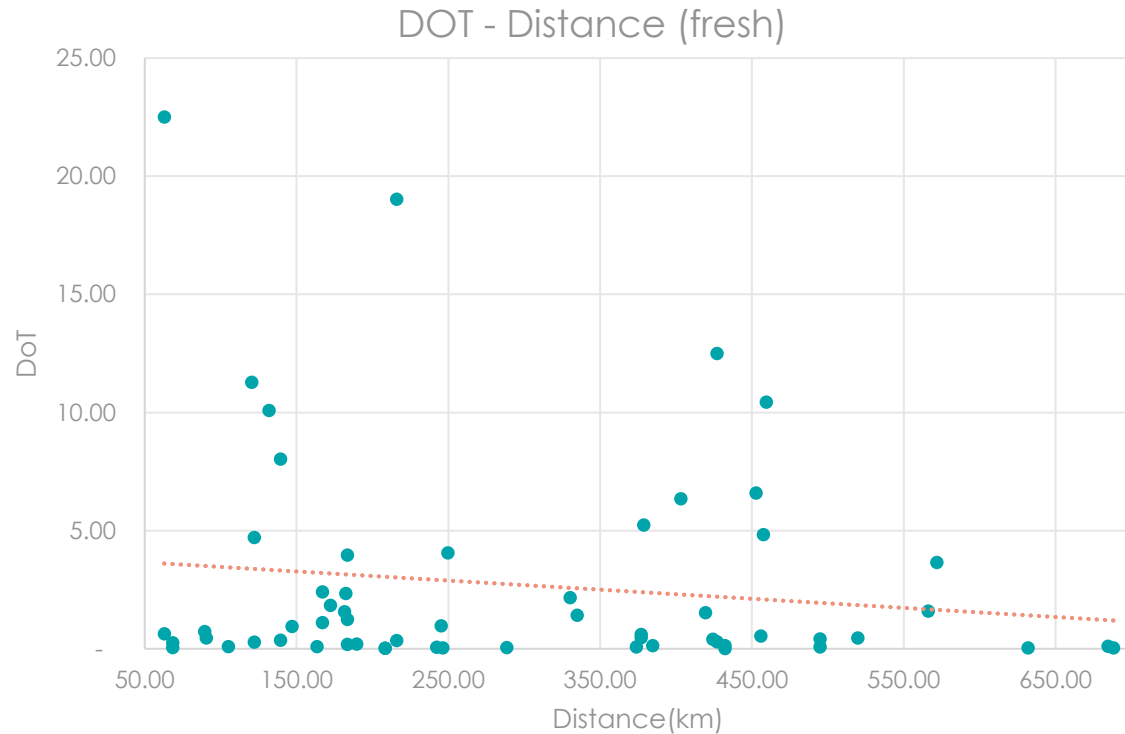


# PROCESSED SARDINELLA DISTRIBUTION

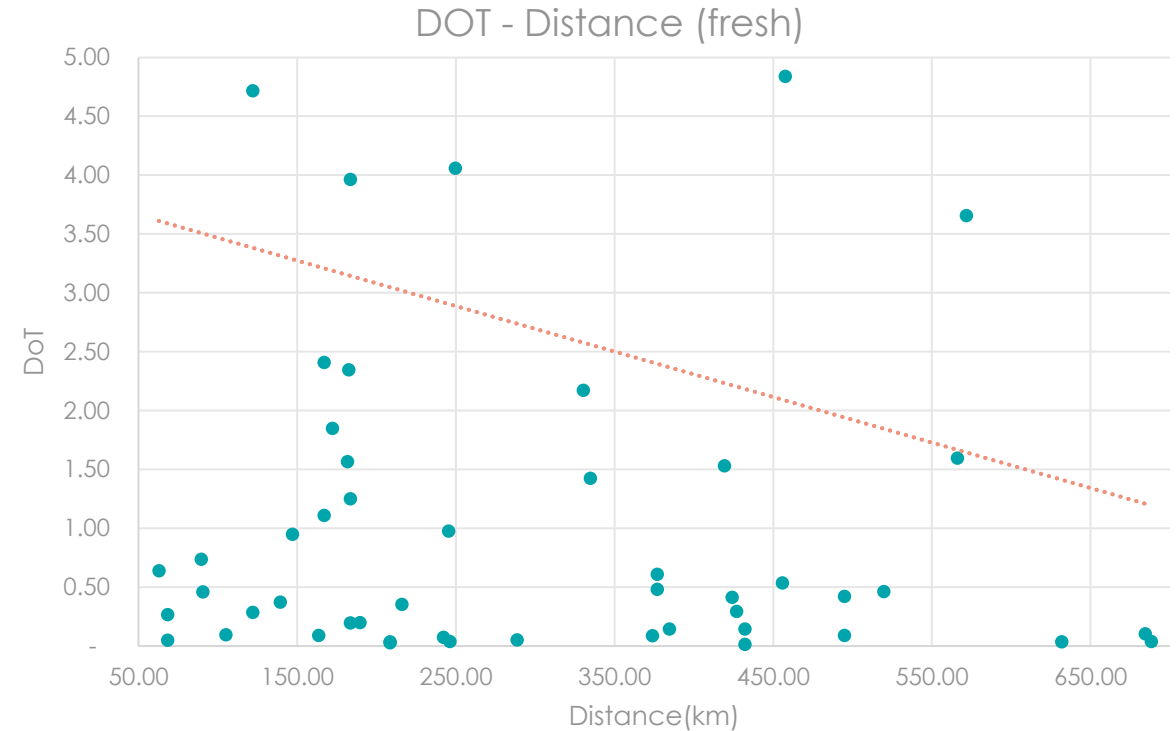


# RESULTS: *DISTANCE OF TRADE(DOT)*

## – *FRESH SARDINELLA*



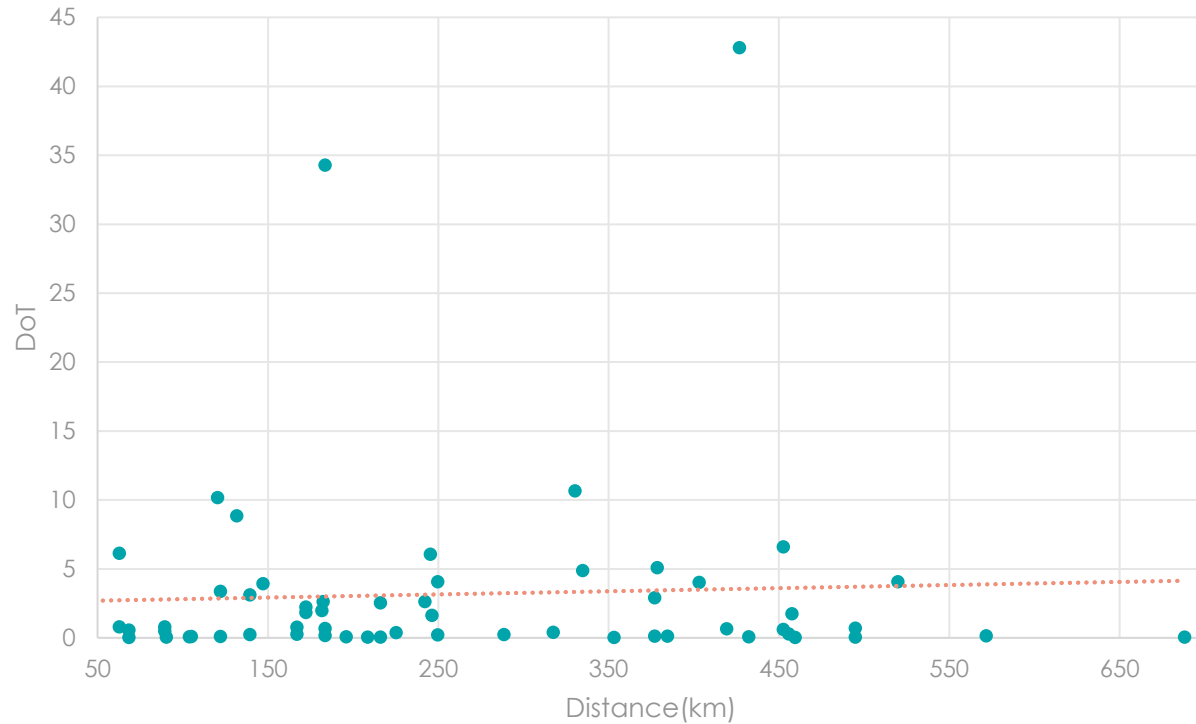
- The plot here shows the correlation between the biomass trade and its travel distance for fresh sardinella. As the distance increases, trade starts to decrease. Whilst there are certain outliers that are to be redistributed. According to the trendline observed, **most biomass stays within the range of 5km (DOT).**



Removal of outliers in the second plot, i.e., which are either a lot of biomass or biomass that travels long distances. Large amounts of biomass that travel long distances show the need for redistribution.

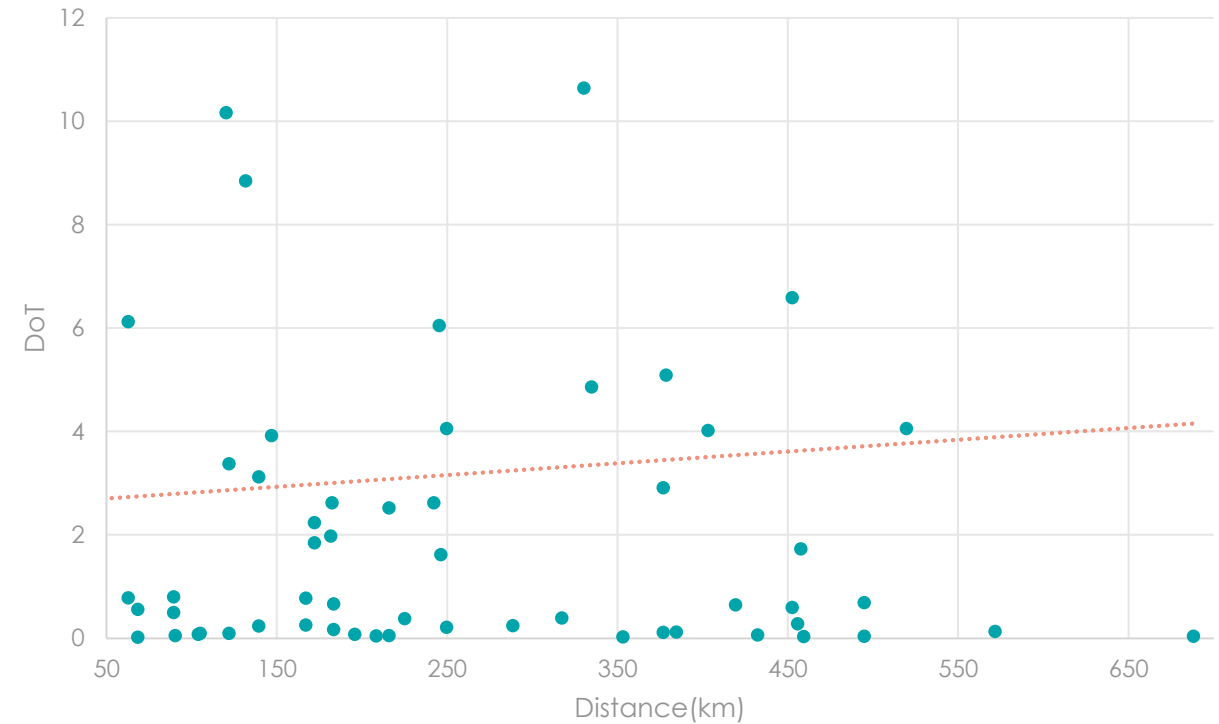
# RESULTS: DISTANCE OF TRADE(DOT) – PROCESSED SARDINELLA

DOT - Distance (processed)



For processed sardinella, the trendline shows a much lower value of DOT i.e., below 3 km.

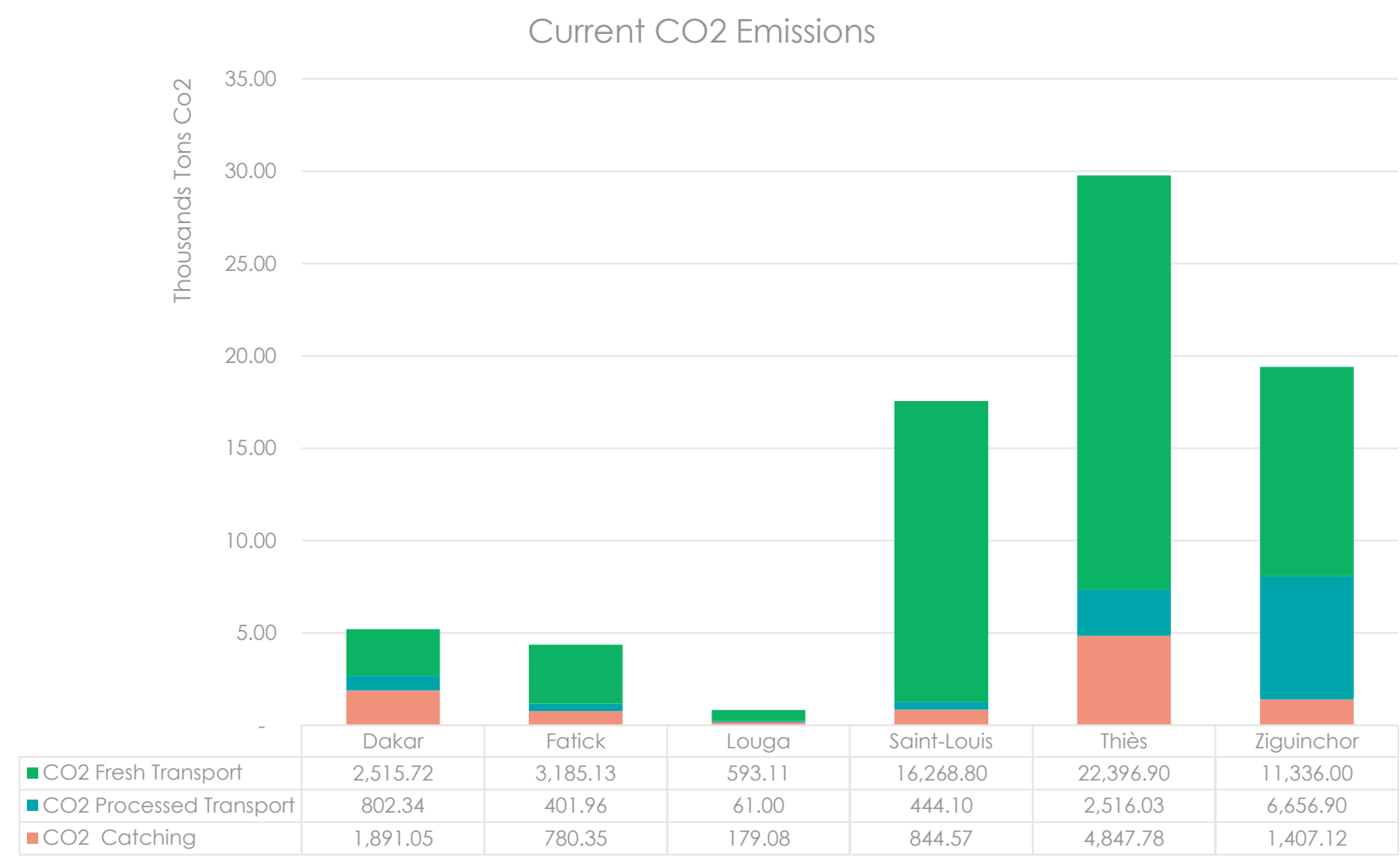
DOT - Distance (processed)



Removal of significant outliers i.e, which are either a lot of biomass or biomass that goes a long distance. Large amounts of biomass that travel long distances show the need for redistribution.



# RESULT: CO2 EMISSIONS FROM CATCHING & TRANSPORTATION



- Estimation of **11,704 Pirogues**
- Total **284 Trucks** Required
- Total CO2 catching: **9,949.94 Tons/year**
- Total CO2 Fresh Sardinella Transport: **56,295.66 Tons/year**
- Total CO2 Processed Sardinella Transport: **10,882.32 Tons/year**

# PROPOSED LOCAL ACTION RESULT

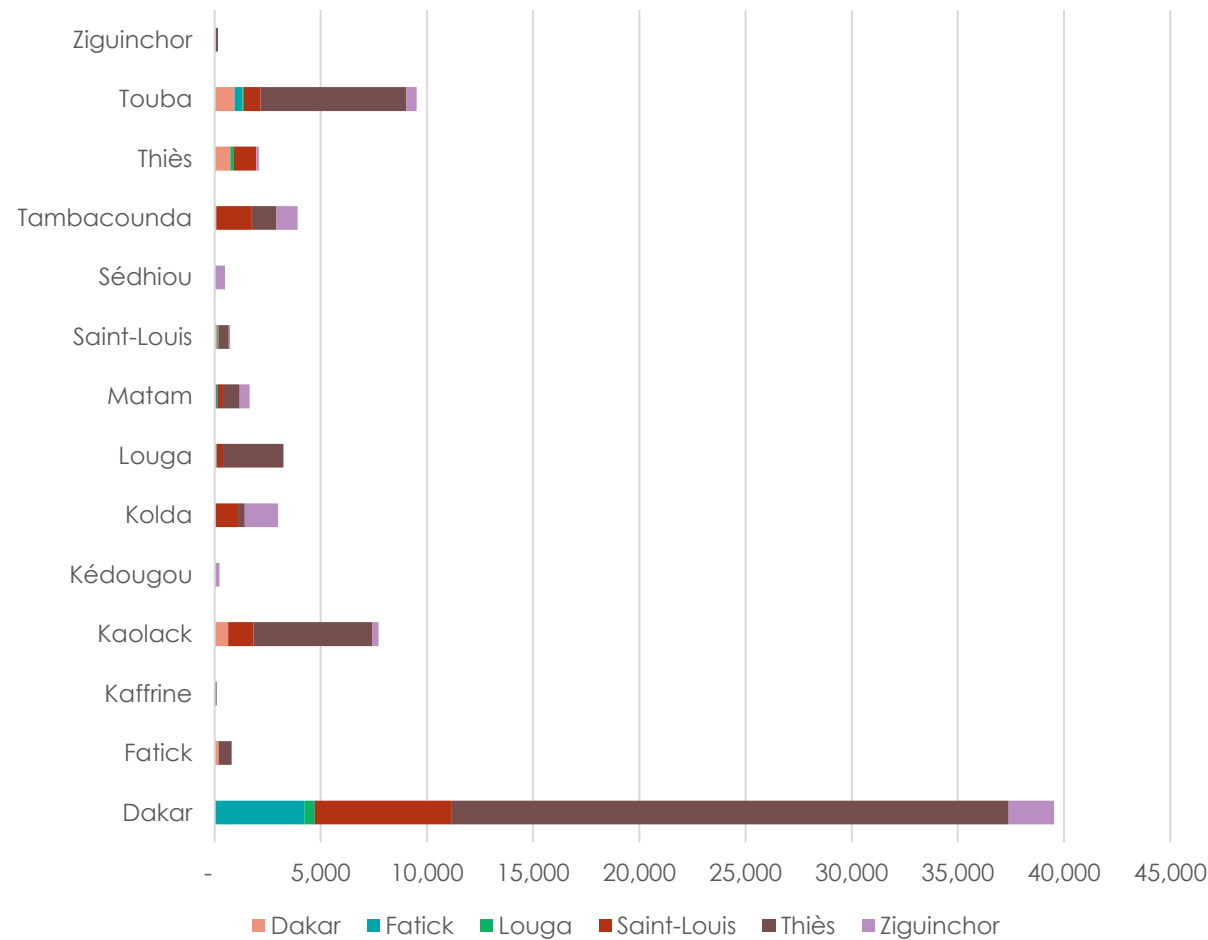
Proposal for transportation efficiency:

- Rearrange distribution and reduce CO2 emissions
- Use existing railway network for redistribution
- Extend railway network

# SHORT TERM: REARRANGE FLOW – FRESH BIOMASS

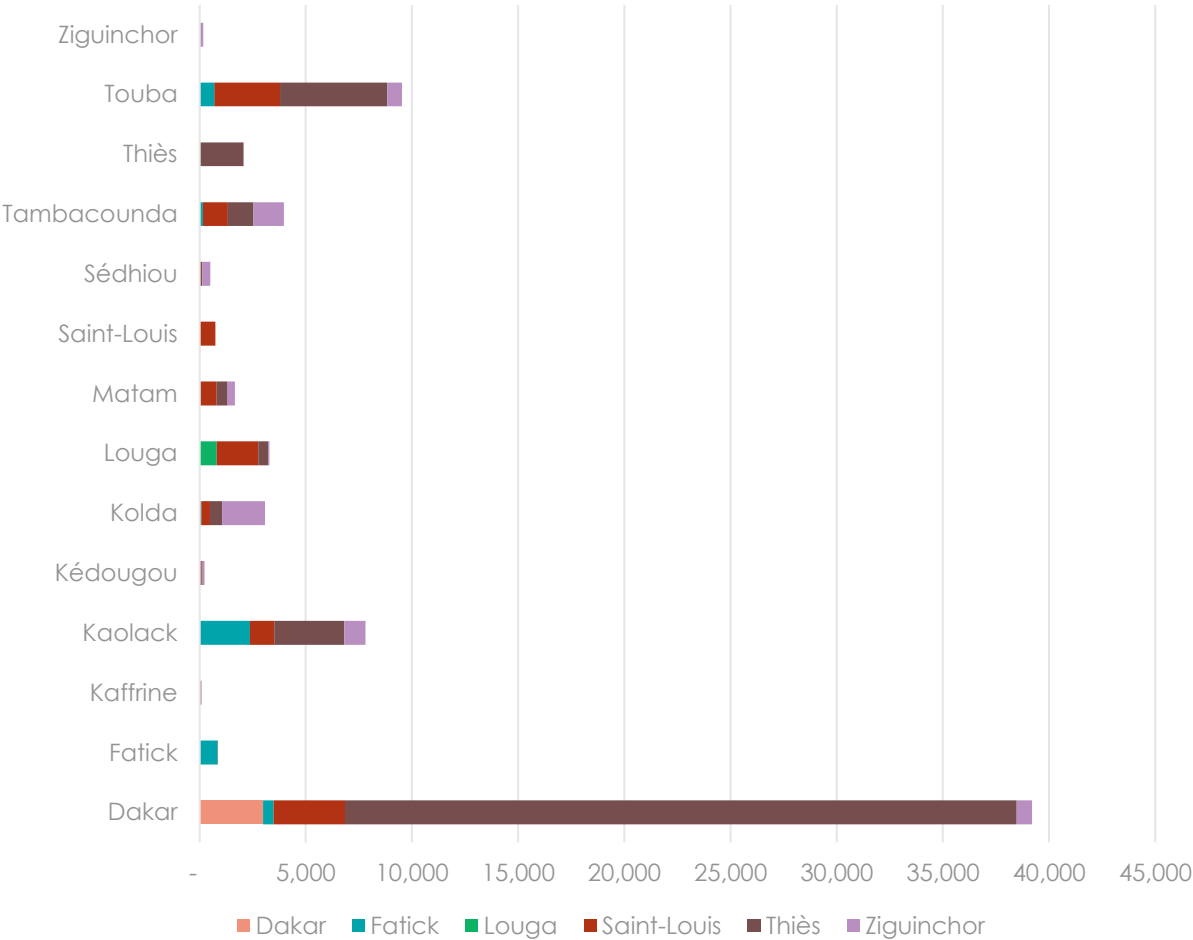
## Current

Origin and Destination of Fresh Sardinella



## Adjusted

Origin and Destination of Fresh Sardinella

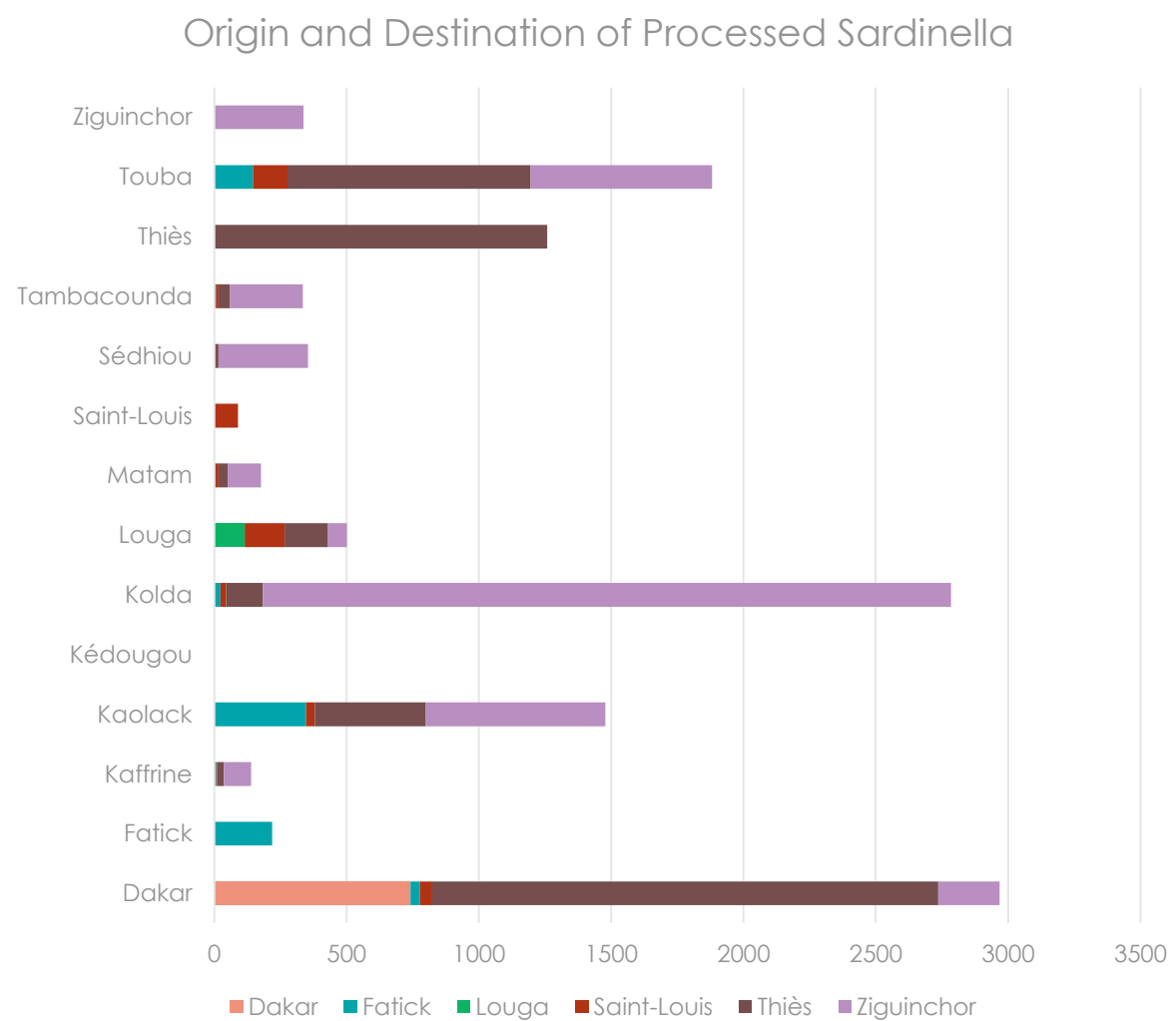
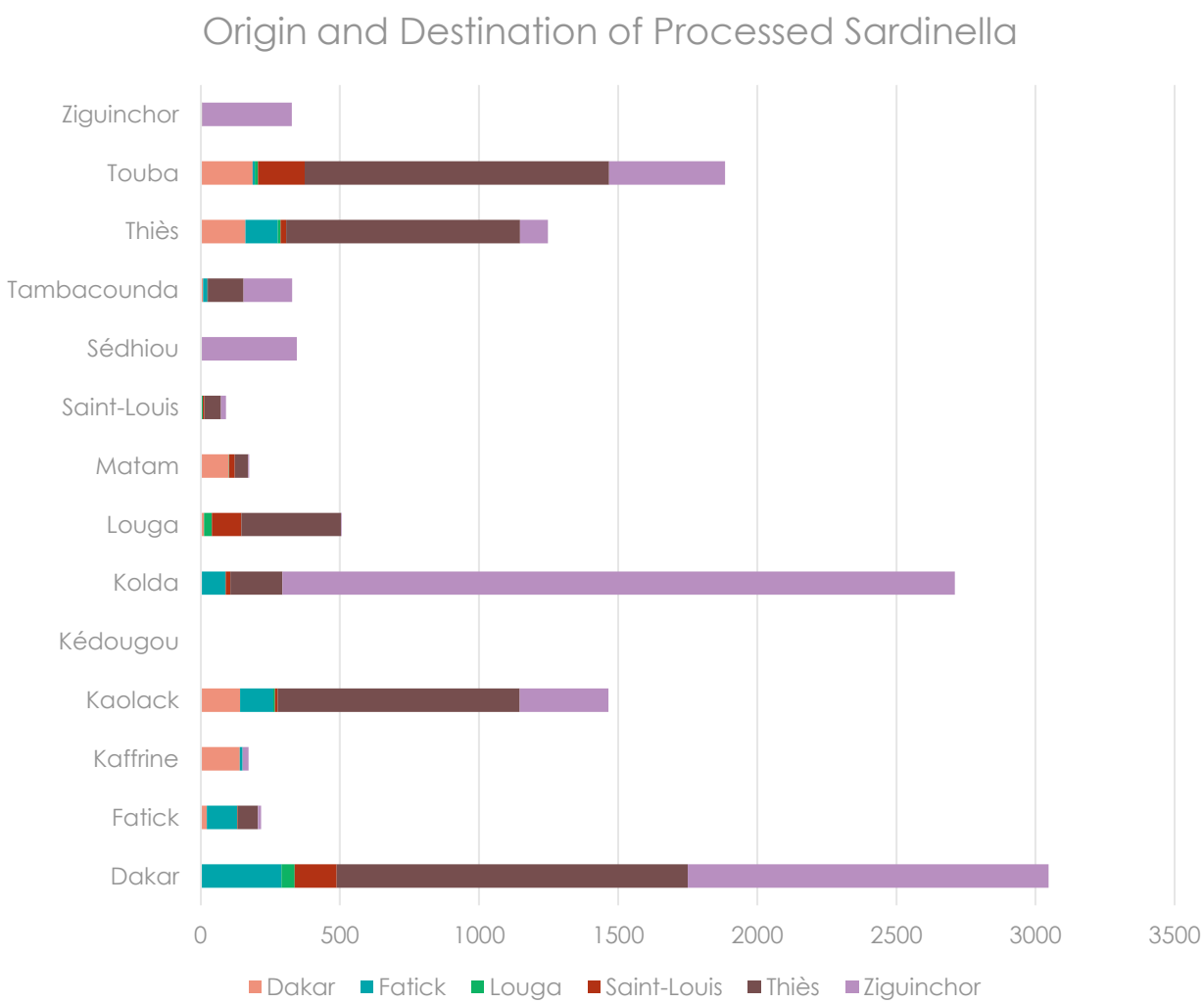


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# SHORT TERM: REARRANGE FLOW – PROCESSED BIOMASS

Current

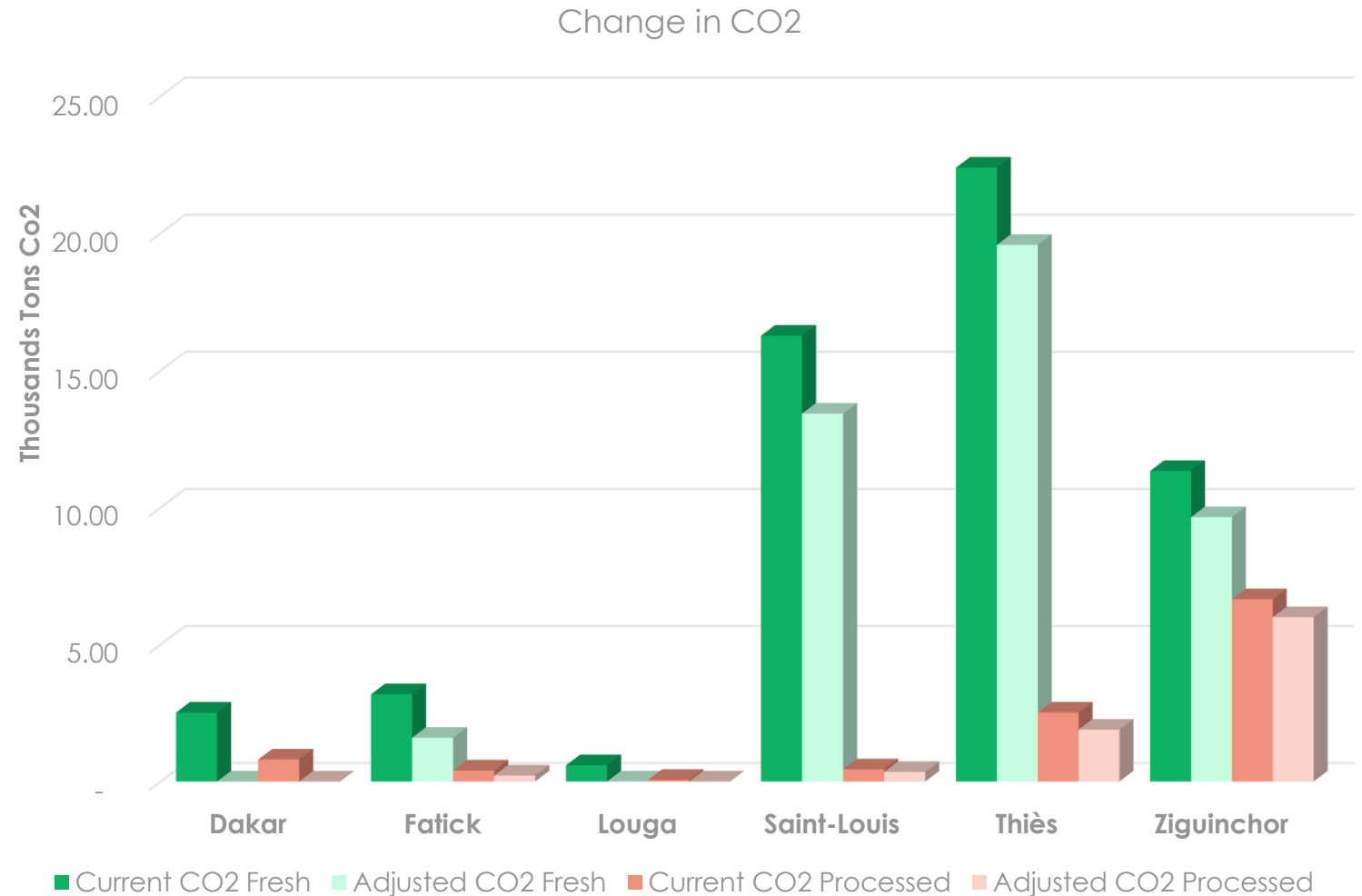
Adjusted



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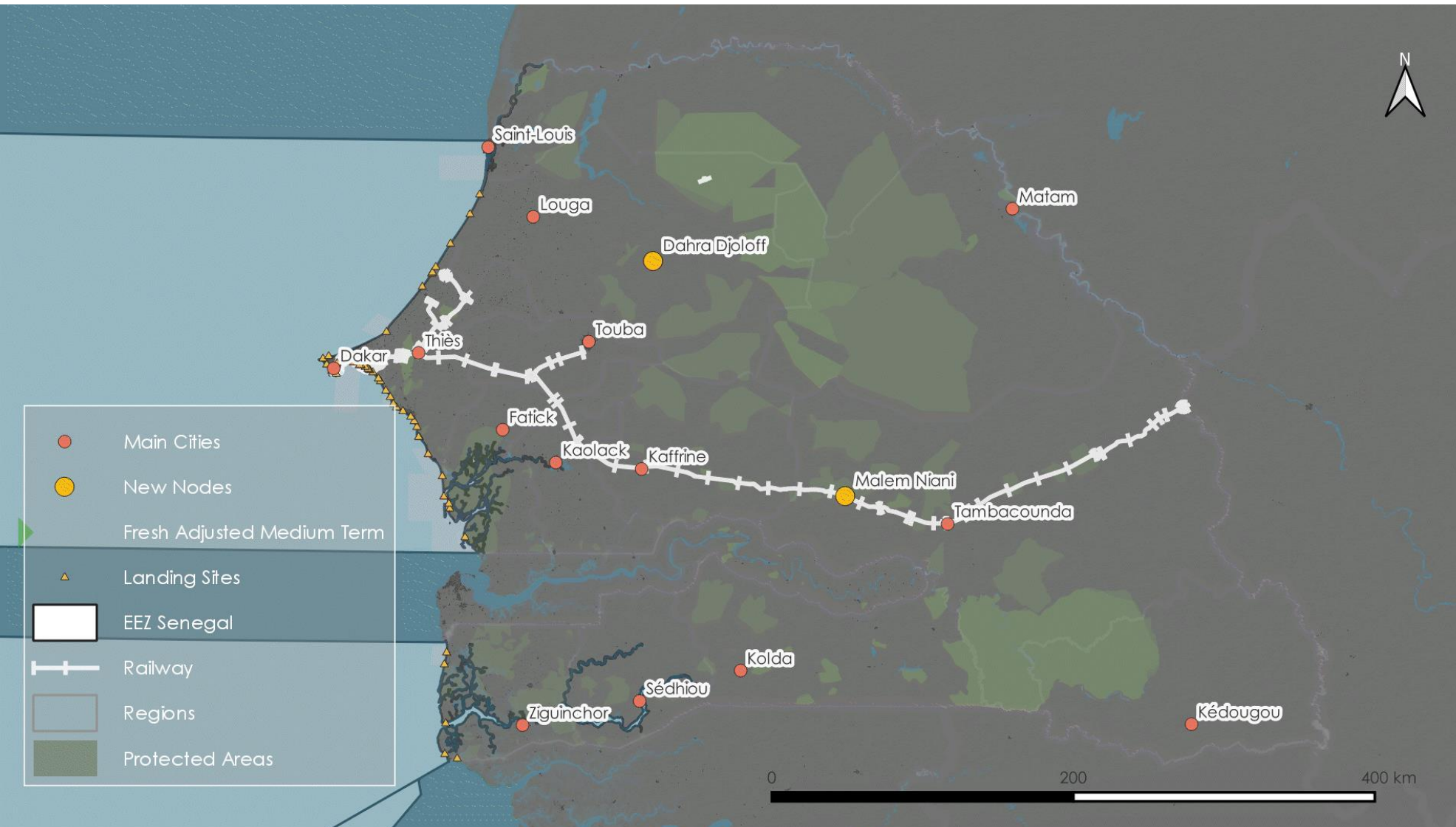
# SHORT TERM: REARRANGE FLOW – CO2 REDUCTION

- **-12,039.51 CO2** Tons/year  
Fresh Transportation
- **-2,427.43 CO2** Tons/year  
Processed Transportation
- **-14,466.95 CO2** Tons/year  
Total Transportation



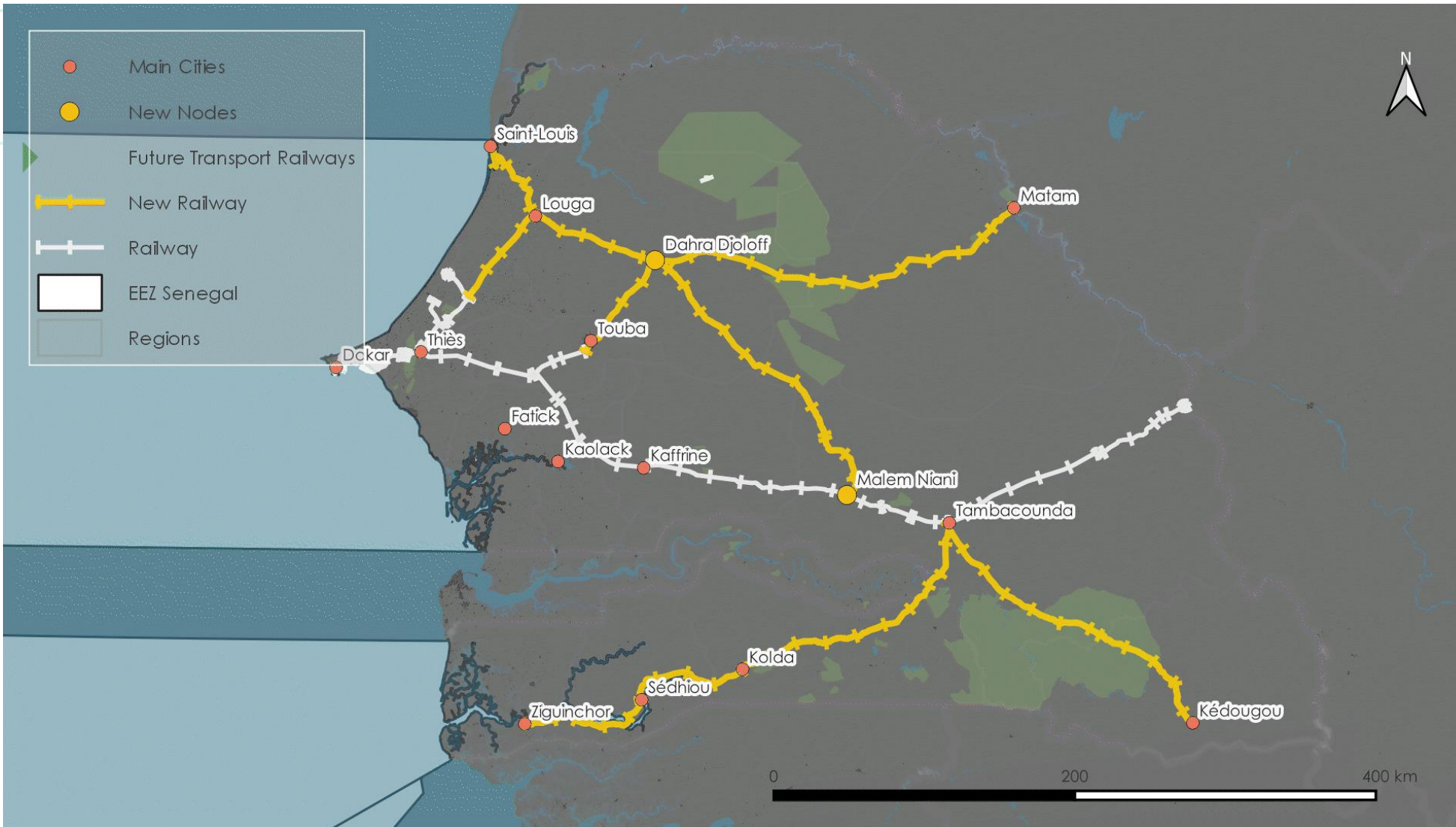


# MEDIUM TERM: REDISTRIBUTION USING RAILWAYS



- Distribution using the **existing railway** will reduce the amount of CO2 emissions further by reducing the number of trucks used since a lot of goods can be transported at once.
- Creation of **two new Nodes** for processing.

# LONG TERM: RAILWAY LINE EXTENTION



- Areas that lack railway networks can connect to the created nodes.
- Increasing **railway connection** to the proposed areas will provide a better means of redistribution and an efficient way for exportation (10 year plan).

# ACHIEVEMENTS



## Food security

The redistribution increases accessibility to food in certain areas.

## Climate change

The reduction of CO2 using the Furness model and railway line reduces CO2

# LIMITATIONS

- A better distribution network does not imply **purchase capability**. 
- By using railways some **jobs can get lost** as truck drivers. 
- There are **143,195 tons** of sardinella exported to other countries which can cover the **113,508 tons** of sardinella deficiency in the whole country. 
- Supplying both fresh and processed fish for **Senegal and other countries** can create **overexploitation** of marine ecosystem services. 

# TASK DISTRIBUTION

	TASKS	DATE	GROUP MEMBER
1	Data retrieval	30-03/2022	Emerald
2	Data Management Plan	01-04/2022	Lakshmi, Iván
3	DOT	08-04/2022	Lakshmi
4	CO2	17-04/2022	Emerald
5	Geo-visualization	17-04/2022	Ivan
6	Proposed strategies	17-04/2022	Ivan
7	Presentation Preparation	20-04/2022	Lakshmi, Iván, Emerald

## Disciplines and Activites

- Lakshmi: Geospatial & Hazard Analysis
- Emerald: Geoinformatics
- Iván: Regional Planning, Cartography

# REFERENCES

- AquaMaps (2019, October). Computer generated distribution maps for *Sardinella aurita* (Round sardinella), with modelled year 2050 native range map based on IPCC RCP8.5 emissions scenario. Retrieved from <https://www.aquamaps.org>.
- Flanders Marine Institute (2019). Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at <http://www.marineregions.org/>.  
<https://doi.org/10.14284/386>
- Marivoet, W., Ulimwengu, J., Sall, L., & Gueye, A. (2021). Hidden hunger: Understanding dietary adequacy in urban and rural food consumption in Senegal. July.
- UNEP-WCMC and IUCN (2022), Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], March 2022, Cambridge, UK: UNEP-WCMC and IUCN. Available at: [www.protectedplanet.net](http://www.protectedplanet.net).
- United Republic of Tanzania (2015). The Importance of Wild Fisheries For Local Food Security : Cambodia. 1–2.





# Appendix 1:Data used

Name of data	Source	Owner	Restrictions and license	Data form	Data format	Contains personal data(Y/N)
Sardinella Aurita spatial extent	Secondary data	OBIS/fish base	Available	Text	CSV	N
Catch of biomass	Secondary data	DPM*-report	Available	Text	PDF	N
Landing sites	Secondary data	PRCM* (2021)	Available	Points	Esri Itemx	N
Urban footprint	Secondary data	Global Human Settlement Layer	Available	Raster; spatial imagery and Census	Geotiff	N
Road Network	Secondary data	Open Street Map	Available	Vector; VGI	Osm	N
Railway network	Secondary data	Open Street Map	Available	Vector; VGI	Osm	N
Exclusive Economic Zones	Secondary data	Flanders Marine Institute (2019).	Available	Vector	Shapefile	N
Protected Areas	Secondary data	UNEP-WCMC and IUCN (2022)*	Available	Vector	Shapefile	N

\*DPM- Direction of Maritime fisheries

\*PRCM-Regional Partnership for Coastal and Marine Conservation (PRCM)

\*UNEP-WCMC AND IUCN-UN Environment Programme World Conservation Monitoring Centre and International Union for Conservation of Nature

# Appendix 2: Furness Model

Current

	Dakar	Fatick	Kaffrine	Kaolack	Kédougou	Kolda	Louga	Matam	Saint-Louis	Sédhiou	Tambacounda	Thiès	Touba	Ziguinchor	Grand Total
Dakar	-	195	22	631	11	27	78	65	119	17	86	744	941	50	2,986
Fatick	4,221	-	-	-	-	11	40	71	12	-	-	-	372	-	4,727
Louga	498	-	-	-	-	-	-	-	52	-	-	171	66	2	789
Saint-Louis	6,447	9	-	1,190	4	1,066	283	267	-	-	1,663	1,055	785	13	12,782
Thiès	26,227	603	76	5,607	4	311	2,829	774	486	-	1,153	-	6,862	93	45,025
Ziguinchor	2,144	13	-	291	206	1,580	24	468	62	472	1,013	118	481	-	6,872
Grand Total	39,537	820	98	7,719	225	2,995	3,254	1,645	731	489	3,915	2,088	9,507	158	73,181

Adjusted

	Dakar	Fatick	Kaffrine	Kaolack	Kédougou	Kolda	Louga	Matam	Saint-Louis	Sédhiou	Tambacounda	Thiès	Touba	Ziguinchor	Grand Total
Dakar	2,986	-	-	-	-	-	-	-	-	-	-	-	-	-	2,986
Fatick	497	847	10	2,364	7	83	21	46	-	11	151	-	691	-	4,728
Louga	-	-	-	-	-	-	787	-	-	-	-	-	1	-	788
Saint-Louis	3,360	-	22	1,156	70	399	1,949	765	739	49	1,175	-	3,097	-	12,781
Thiès	31,636	1	39	3,303	66	581	487	511	-	73	1,215	2,064	5,048	-	45,024
Ziguinchor	712	-	29	991	86	2,010	40	341	-	370	1,433	-	697	164	6,873
Grand Total	39,191	848	100	7,814	229	3,073	3,284	1,663	739	503	3,974	2,064	9,534	164	73,180