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OPTIMISATION OF SUPPLY CHAIN OF TARGETED PUBLIC DISTRIBUTION SYSTEM

IN DHENKANAL, ODISHA

PROOF OF CONCEPT 2018

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OPTIMISATION OF TPDS SUPPLY CHAIN

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Acknowledgement

The World Food Programme (WFP) is the largest humanitarian organisation working in emergencies and development contexts supporting over 80 million people worldwide through essential food, school meals, cash transfers and technical assistance. To ensure that we deliver every day in over 80 countries, supply chain plays an integral role; supporting the entire process of end-to-end planning, procuring and delivering assistance.

Inline with our efforts in ensuring a smooth, well functioning and efficient supply chain, WFP have been investing in innvoting and developing solutions that help optimise our supply chains to reduce operational, administrative and financial costs. This proof of concept for optimisation of the supply chain of TPDS in Dhenkanal, Odisha is a step in the same direction.

I would like to express my gratitude to the Food Supplies and Consumer Welfare Department (FS&CWD), Odisha led by Mr. Vir Vikram Yadav, Secretary (FS&CWD) for their support in completing this activity. I would also like to congratulate Mr. Yadav and his team for their initiate to pioneer optimisation of supply chains in TPDS in India, which I hope will serve as a guide to other states.

Lastly, a special gratitude to the Supply Chain and Planning team in WFP, Rome and the System Reforms Unit in WFP, India for conceptualising and implementing various scenarios to optimise the exsiting supply chain. I am happy to share this report which details the process, methodology and results of the optimisation of TPDS for Dhenkanal, Odisha.

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Foreword

The Department of Food Supplies and Consumer Welfare, Government of Odisha, is committed to provide food security to the poor, distressed & eligible people in the State. Odisha has been one of the pioneering States in achieving End-to-End computerization of the Targeted Public Distribution System (TPDS) and implementation of the National Food Security Act 2013 (NFSA).

Serving over 32 million beneficiaries across 30 districts through TPDS, the State has taken several steps to not only ensure effective implementation of the Food Security Schemes but to also explore ways of evolving its systems to ensure transparency and efficiency in the delivery of its services. One of the ways, the Odisha Government has tried to achieve this is through reforming and digitising the entire procurement and distribution systems under TPDS.

An endeavor of this scale requires support and collaboration of many stakeholders. We are happy that the United Nation's World Food Programme has been a constant partner in our efforts. WFP has been working closely with the State Government, bringing its national and international expertise to fuel the momentum of this reform process. As a part of the collaboration, WFP on the advice of Government of Odisha undertook a Proof of Concept (PoC) to shed light on ways in which the supply chain of the Public Distribution System can be optimized for better utilization of existing resources in the district of Dhenkanal, Odisha.

I am sure this exercise would be beneficial in augmenting the resources, which can further be used to benefit TPDS beneficiaries.

(Vir Vikram Yadav)

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SAVING LIVES
CHANGING LIVES

Foreword

The United Nations World Food Programme (WFP) has been working closely with the Government of India since 1963, supporting the Government in its endeavor to provide food and nutrition security to the most vulnerable. Over the decades, WFP's role has evolved from a food aid agency to a technical partner for the Government. WFP's association with the Government of Odisha was initiated in 2007 and in the recent years, WFP has supported the state government in implementation of the National Food Security Act, 2013 and in the transformation of its Targeted Public Distribution System (TPDS) to be fully digitized and automated, enabling it to become more transparent, accountable and efficient.

In line with this initiative, WFP undertook an assessment in collaboration with the Government of Odisha in 2017, to review the procurement and supply chain system as well as of the Paddy Procurement Automation System (P-PAS) and Supply Chain Management System (SCMS) solutions of TPDS in the state. The assessment report recommended a business process review of the existing P-PAS and SCMS systems to enhance and integrate the two, as well as the optimization of the entire supply chain to make it more efficient and reduce underutilization of resources.

Based on the recommendations of the report and on Government of Odisha's request, an assessment was conducted in early 2018 to determine optimization opportunities in Odisha and collect data for establishing a Proof of Concept (PoC) for optimization of the supply chain. Dhenkanal district of Odisha, which has 9,28,000 TPDS beneficiaries out of 3.26 crores in Odisha was chosen for the PoC.

The aim of this PoC is to demonstrate the savings potential through optimizing the supply chain by applying WFP's operations research approach and tools, leading to efficiency improvements in the procurement, storage and delivery of food grains. The PoC analyses different scenarios and finds that in a fully optimized scenario, cost savings of 29 per cent on the current costs can be achieved.

This process has enormous potential to turn underutilization of resources into assets and savings, which can be further used to reach the beneficiaries more effectively and help them gain more from the TPDS. I hope this analysis will be helpful for the Government of Odisha in creating an optimized supply chain network across the state to better manage food grain flows for all food safety nets in Odisha.

I would like to congratulate the Government of Odisha for its commitment and remarkable progress in building an efficient public distribution system and introducing cutting edge technology to the entire value chain from procurement to distribution. WFP looks forward to a continued and strong partnership with the Government of Odisha, towards the common objective to improve access to safe and nutritious food for all.

Hameed

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LIST OF ABBREVIATIONS

CTC	-	Change in Transport Contracting
EtE	-	End-to-End
FCI	-	Food Corporation of India
FPS	-	Fair Price Shop
FSCW	-	Food Supplies and Consumer Welfare Department
GMP	-	Good Manufacturing Practices
GoO	-	Government of Odisha
KPI	-	Key Performance Indicator
MSP	-	Minimum Support Price
NFSA	-	National Food Security Act
PACS	-	Primary Agriculture Credit Society
PoC	-	Proof of Concept
P-PAS	-	Paddy Procurement Automation System
PPC	-	Paddy Purchase Centre
RRC	-	Rice Receiving Centre
SCMS	-	Supply Chain Management System
SHF	-	Small Holder Farmers
TPDS	-	Targeted Public Distribution System
WFP	-	World Food Programme

MILLS

Mill1	-	Annapurna Rice Mill
Mill2	-	BDN Food Products
Mill3	-	Bhutia Foods Pvt. Ltd.
Mill4	-	Harpriya Rice Mill
Mill5	-	Kamlesh Rice Mill
Mill6	-	Laxminarayan Agro Foods
Mill7	-	Maa Kamakhi Food Processor
Mill8	-	Maa Tarini Rice Mills
Mill9	-	Natural Agritech Pvt. Ltd.
Mill10	-	Panchasakha Rice Mill
Mill11	-	Santoshi Rice Mill
Mill12	-	Tareni Agro Foods

RRC

RRC1	-	Badasuanlo
RRC2	-	Baladiabandha
RRC3	-	Barihapur
RRC4	-	Basoi
RRC5	-	Bhubhan
RRC6	-	Dhenkanal
RRC7	-	Gondia
RRC8	-	Hindol
RRC9	-	Mahispat (I)
RRC10	-	Mahispat (II)

TABLE OF CONVERSION

Kg. – Kilograms, Qtl. - Quintals, Rs. - Rupees, Km. - Kilometers

- 1 Metric Tonne = 10 Quintals
- 1 Quintal = 100 Kgs.
- 1 Million = 10 Lakhs
- 1$ = ~ 65 Rs. (at the time of analysis)
- 1 Mile = 1.61 Km.

KEY DEFINITIONS

Clustering- Is a task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters). For this analysis clustering refers to grouping of a set of nodes to minimise cost and distance.

Nodes- Nodes refer to the various originating and destination locations in the overall supply chain. For example: PACS, mills, RRCs etc. are all nodes.

Supply Zone- A supply zone is an area within which all nodes which are part of a cluster are located. The area cannot be defined by any administrative boundaries.

Tagging- Tagging is a method of allocating (delivery and quantity) destination node to origin node within the supply chain.

Throughput- Throughput is the maximum output over a defined period of time.

L1 transporter- The transport contractor that operates between Food Corporation of India warehouses and the state-run warehouses or between two state run warehouses for the TPDS scheme.

L2 transporter- The transport contractor that operates between state run warehouses and fair price shops for the TPDS scheme.

Greedy Algorithms- A greedy algorithm always makes the choice that seems to be the best at that moment. This means that it makes a locally-optimal choice in the hope that this choice will lead to a globally-optimal solution.

CHAPTER 1

1. EXECUTIVE SUMMARY

Government of Odisha (GoO) has made remarkable progress and enhancements to the Targeted Public Distribution System (TPDS) of the state since the adoption of the National Food Security Act' 2013 (NFSA) and the implementation of End-to-End (EtE) computerisation of the TPDS. As part of this process, the procurement and distribution systems for TPDS have been digitised and automated. In an endeavor to make these systems even more efficient, accountable and transparent at the request of GoO, World Food Programme (WFP) undertook an assessment of the entire procurement and distribution operations as well as the deployed software systems i.e. Paddy Procurement Automation System (P-PAS) and the Supply Chain Management System (SCMS), during April, 2017[1] .

The core recommendations of WFP's assesment included a comprehensive business process review of the SCMS and P-PAS system to enhance and integrate the two systems. The report also suggested stringent measures to improve quality control, introduction of requisite infrastructure at PACS, introduction and adherence to Good Manufacturing Practices (GMP) at mills and improvement in warehouse management at Rice Receiving Centres (RRC). Lastly, a study to access the overall supply chain including farmers, PACS, mills, warehouses and FPS from an operational research perspective to optimise the entire network was also recommended.

In line with these recommendations, a WFP mission comprising of supply chain and operational research experts completed field assessments and stakeholder consultations in December 2017. The mission's objectives were to identify optimisation opportunities, understand operational processes, data availability and further suggest a potential roadmap for implementation of the optimised supply chain setup.

The december mission observed that the existing network planning and tagging was based on proximity, administrative boundaries, and other 'greedy algorithms[2], which resulted in inefficiencies in the overall supply chain and underutilisation of resources. The mission further suggested that an incremental approach for supply chain optimisation be adopted, within which initially a proof of concept (PoC) to demonstrate savings potential of optimisation should be completed. Based on the outputs of the PoC, the state may further choose to either implement the findings in one district to realise actual savings or develop a structural solution which can be implemented in the entire state.

Dhenkanal district was chosen for the initial PoC since GoO had already completed data collection including geocodes for the entire TPDS supply chain of Dhenkanal. Dhenkanal district, which is located in the central part of Odisha has 9.28 lakh TPDS beneficiaries with a requirement of 45000 quintals of rice and 8000 quintals of wheat monthly. The beneficiaries are served by 565 Fair Price Shops (FPS). The district also has 10 RRCs, 1 Food Corporation of India (FCI) warehouse to store the food grains (rice and wheat) and 12 mills that mill the paddy procured at 80 PACS in the district.

To complete the PoC, WFP prioritised, structured and analysed data as well as applied the optimisation algorithm to execute various scenarios within the given constraints. The figure below describes the methodology used for arriving at the outputs.

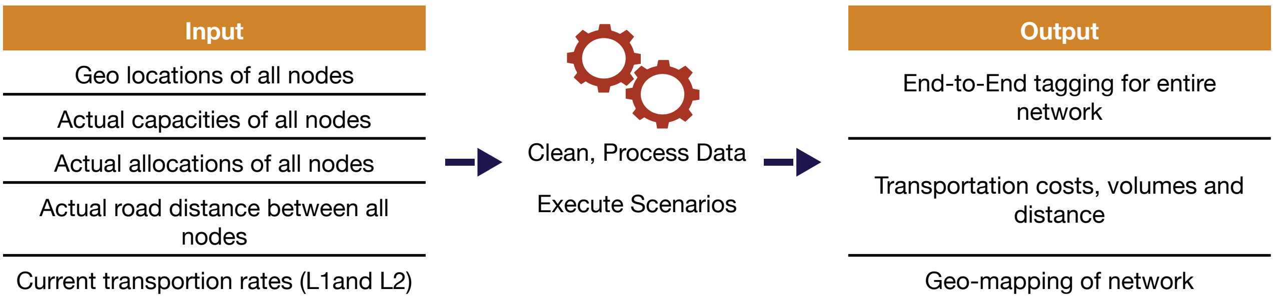


Figure 1: Process for the proof of concept for optimisation of supply chain of TPDS, Dhenkanal

1.1. KEY FINDINGS

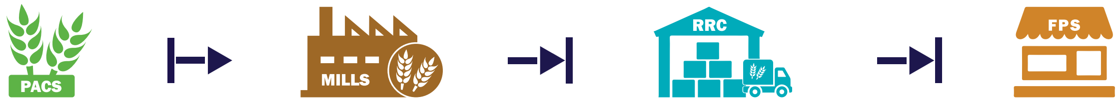
A total of ten scenarios were executed with different perspectives and constraints, which showed that savings between 2-29% with respect to the baseline costs could be achieved. In the fully optimised scenario, keeping the number and allocation of PACS and FPS exactly same as in the current situation (baseline), while changing the tagging and allocation of all other intermediate nodes i.e. mills and warehouses, **cost savings of 29%** could be achieved. The report also compares the baseline to nine other scenarios, to inform the state on the methodology, results from variations in tagging and allocation at each node, the cost savings that can be achieved in each scenario as well as provide options to the government for implementation based on their needs and aspirations.

[1] https://docs.wfp.org/api/documents/WFP-0000040040/download
[2] A greedy algorithm always makes the choice that seems to be the best at that moment. This means that it makes a locally-optimal choice in the hope that this choice will lead to a globally-optimal solution.

Additionally, the analysis found that by changing just the payment modality for transportation from RRC to FPS, from the 'per Qtl.' to 'per Qtl. per Km.' and using the rates as in the Mill to RRC leg itself lead to a saving of 19% from the current costs. The savings potential clearly indicates the need to review and revise the existing operational practices and policies with respect to the supply chain system, in a bid to achieve cost savings which can be reutilised for further benefit of the beneficiaries. Summary of the changes in the network in each scenario and the savings that can be achieved are described below:

SCENARIO : BASELINE

GOAL: Model the existing network to calculate costs and prepare a base for comparison with other scenarios.

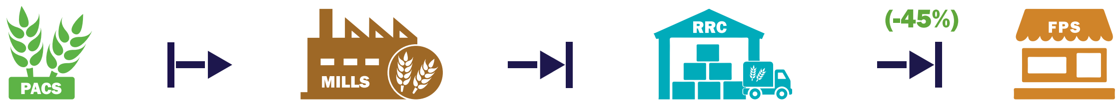


TOTAL COSTS AND SAVINGS : RS. 45,71,640

SCENARIO 1: BASELINE WITH CHANGE IN TRANSPORT PAYMENT MODALITY

GOAL: Investigate potential savings with change in transporter payment modality and rates from per Qtl. to per Qtl. per Km. in RRC to FPS transport.

KEY RESULT: Cost saving of 45% in the last leg i.e. from RRC to FPS.

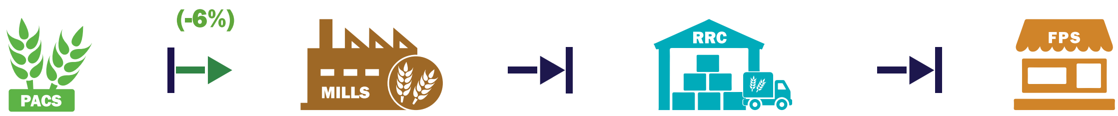


TOTAL COSTS AND SAVINGS : RS. 36,95,980 (-19%)

SCENARIO 2: OPTIMISE PACS TAGGING

GOAL: Investigate potential savings by only changing the PACS tagging (assuming mill throughput is kept equal).

KEY RESULT: Tagging of 52 out of 80 PACS is changed resulting in average distance/Qtl. to decrease from 19.5 to 17.9 Km. in the leg 1 i.e. PACS to Mill.

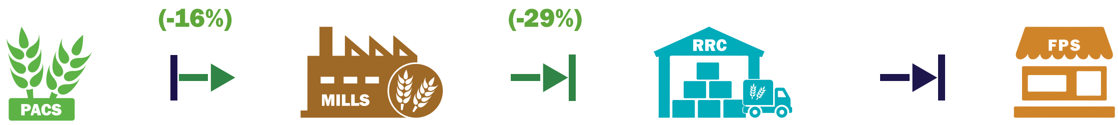


TOTAL COSTS AND SAVINGS : RS. 44,84,219 (-2%)

SCENARIO 3: OPTIMISE LEG 1 AND 2

GOAL: Investigate potential savings by changing the PACS to Mill and Mill to RRC tagging (assuming mill throughput can change as well).

KEY RESULT: Tagging of 56 out of 80 PACS is changed. Average distance/Qtl. decreased from 19.5 to 13.5 Km in the PACS to Mill leg and from 19.2 to 11.9 Km. in the Mill to RRC leg



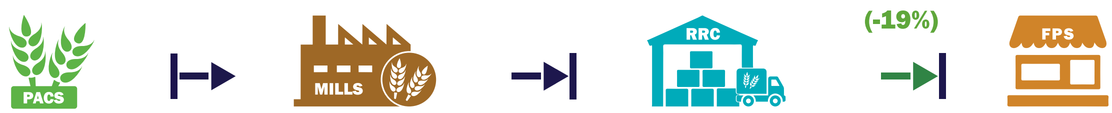
TOTAL COSTS AND SAVINGS : RS. 40,63,924 (-11%)

Can be changed *Remains the same* *Can be closed*

SCENARIO 4: OPTIMISE FPS TAGGING

GOAL: Investigate potential savings by only changing the FPS tagging (assuming the transport rate in the last leg is changed from the 'per Qtl.' to 'per Qtl. per Km').

KEY RESULT: Tagging of 356 out of 565 FPS is changed which results in a decrease in average distance/ Qtl. from 22.4 to 18.1 Km. in the RRC to FPS leg.

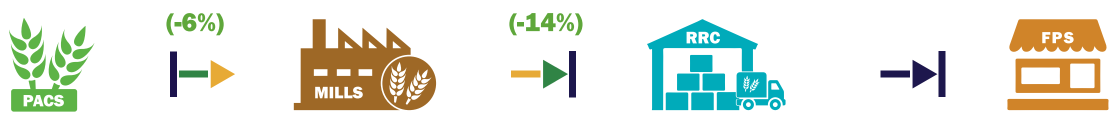


TOTAL COSTS AND SAVINGS : RS. 41,80,933 (-9%)

SCENARIO 5: CLOSING MILLS

GOAL: Investigate what mills should be used in order to minimise transportation costs assuming that all mills should either use their full capacity or be closed.

KEY RESULT: 6 out of 12 mills are closed, the average distance/Qtl has reduced from 19.5 Km. to 15.13 Km. in PACS to Mill leg and from 19.24 Km. to 15.78 Km. in Mill to RRC leg.

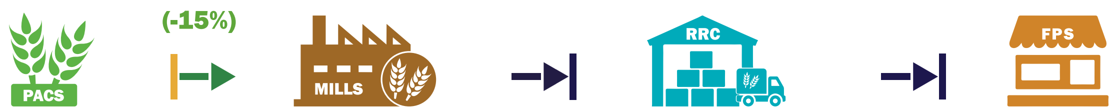


TOTAL COSTS AND SAVINGS : RS. 42,92,075 (-6%)

SCENARIO 6: CLOSING PACS

GOAL: Investigate what PACS should be closed in order to minimise transportation costs, assuming that all PACS are able to supply their maximum capacity.

KEY RESULT: 12 out of 80 PACS are closed resulting in an average distance/Qtl. decrease from 19.5 km. to 13.6 Km. in the PACS to Mill leg.

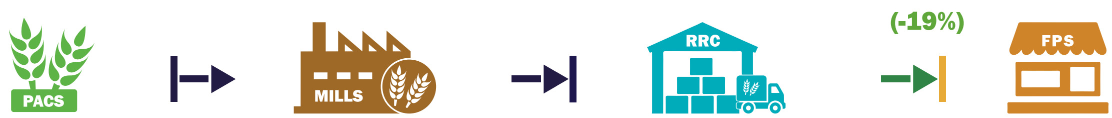


TOTAL COSTS AND SAVINGS : RS. 43,23,411 (-5%)

SCENARIO 7: CLOSING FPS

GOAL: Investigate the effect on the transportation costs as the optimiser chooses to close the small FPS (<35 Qtl.) and shift their demand to another FPS that is close by (within 2 Km.).

KEY RESULT: 59 out of 565 FPS are closed resulting in a decrease in average distance/Qtl. from 21.67 km. to 17.34 km for the RRC to FPS leg.



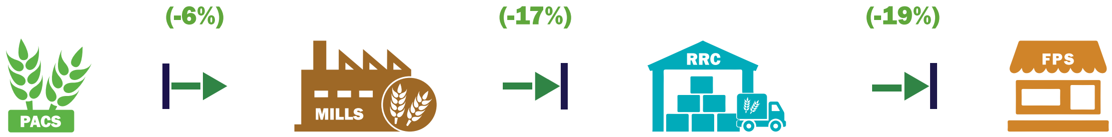
TOTAL COSTS AND SAVINGS : RS.41,79,980 (-9%)

Can be changed   *Remains the same*   *Can be closed*

SCENARIO 8: FULLY OPTIMISED WITH CAPACITY CONSTRAINED

GOAL: Investigate how much savings can be achieved in the transportation cost by chnaging the tagging of all the nodes and assuming that the throughput of all locations (RRCs and mills) remain the same.

KEY RESULT: Tagging of 52 out of 80 PACS and 356 out of 565 FPS is changed. This results in an average distance/Qtl. decreases by 6%, 17% and 19% respectively in the three legs.

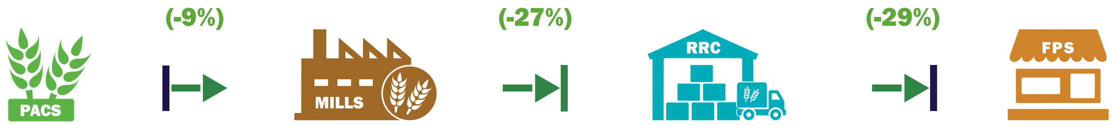


TOTAL COSTS AND SAVINGS : RS. 39,37,544 (-14%)

SCENARIO 9: FULLY OPTIMISED WITH CAPACITY CONSTRAINED +15%

GOAL: Investigate how much savings can be achieved by changing the tagging and assuming that each location in the network (mills and RRCs) can handle up to 15% more than the current throughput.

KEY RESULT: Centrally located mills and RRCs are being used more heavily resulting in an average distance/Qtl. decrease by 9%, 27% and 29% respectively in the three legs.

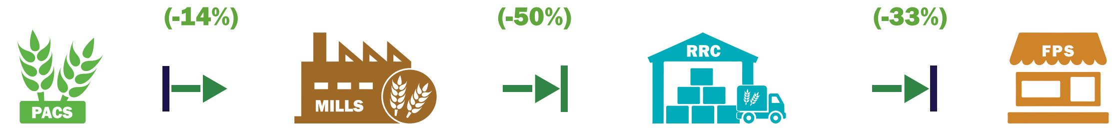


TOTAL COSTS AND SAVINGS : RS. 36,06,288 (-21%)

SCENARIO 10: FULLY OPTIMISED

GOAL: Investigate how much savings are possible by allowing the tagging and throughput of every location in the network to change (mills should not exceed capacity)

KEY RESULT: The throughput volume of almost all locations is changed resulting in an average distance/ Qtl. decrease of 14%, 50% and 33% respectively in the three legs.



TOTAL COSTS AND SAVINGS : RS. 32,48,206 (-29%)

● *Can be changed* ● *Remains the same* ● *Can be closed*

Table 1: Summary of scenarios and results

INTRODUCTION

2

CHAPTER

2. INTRODUCTION

Odisha procures approximately 60 lakh metric tonnes of paddy in a year, out of which 21 lakh metric tonnes is utilised within the state for meeting the needs of rice under various food subsidy schemes. The Targeted Public Distribution System (TPDS), which is the largest amongst the food subsidy schemes, provides subsidised food to 3.26 crore beneficiaries in the state. TPDS is operated under the joint responsibility of the state and national government, however, Odisha being a decentralised procurement state[3], is responsible for the procurement and milling of paddy, storage of both wheat and rice as well as subsequent transportation to Food Corporation of India (FCI) and Fair Price Shops (FPS) for distribution to the beneficiaries in the state.

Key features of the supply chain setup in Odisha are as below.

Supply Chain	Procurement (PACS to Mills) →	Processing (Mills) →	Storage (Mills to RRC and FCI to RRC) →	Delivery (RRC to FPS)
Key Stakeholders and Operations	**Primary Agriculture Credit Societies (PACS)** are the cooperatives assigned by the Government of Odisha to setup paddy purchase centres (PPC), where farmers come to sell the paddy for receiving minimum support price (MSP).	Mills process the paddy to produce rice at an agreed efficiency of 68%.	RRCs store food grains before they get delivered to FPS.	**FPSs** receive rice and wheat that is stored at the RRCs for distribution to beneficiaries.
	Farmers register at the PACS at the start of the procurement season to receive MSP for their produce.	After the rice is processes it is transported to one of the **Rice Receiving Centers (RRC)**	RRCs receive wheat from **FCI**. RRCs also receive rice from FCI in deficit districts and send rice from surplus districts to FCI.	The supplying RRC depends on the block where the FPS is located.
Number of Stakeholders	~10 Lakh Farmers registered in the system 2,700 PACS	~1,500 Mills	225 RRCs 56 FCI Warehouses	~13,000 FPS 3.26 crore beneficiaries
Transportation Costs	**Mills** are responsible for picking up the paddy at the PACS. Govt. compensates the miller's dependent on the distance and volume of paddy picked up from PACS. **i.e. Cost per Qtl. per Km**.	Transportation costs for Mill to Rice Receiving Centres (RRC) is dependent on the distance and volumes, however, the rate is not same as that for transportation between PACS to Mill. **i.e. Cost per Qtl. per Km.**	Transport costs from RRC to RRC and from FCI to RRC is defined through a workable rate with price fixed (through L1 contracting) per Qtl. based on distance range. **i.e. Cost per Qtl. (distance range)**	The transportation costs in this final leg are different for every block and depend only on volume. **i.e. Cost per Qtl.**

Table 2: Key features of the supply chain in Odisha

Within the purview of the National Food Security Act (NFSA)' 2013 and the End-to-End (EtE) computerisation of TPDS, entire procurement, storage and distribution (supply chain) operations of Odisha have been reformed and digitised using software applications including Paddy Procurement Automation System (P-PAS), Supply Chain Management System SCMS etc. While, the P-PAS system integrates the entire procurement processes including farmer registration, procurement of paddy, quality checks, miller operations as well as farmer payments, the SCMS integrates all the supply chain and storage operations between Mill to RRC and from RRC to FPS. WFP has been a partner to the GoO since 2008 and has supported the EtE computerisation of the exsiting system, thereby bringing in efficiency on the ground and accountability, transparency in the entire system. In April 2017, World Food Programme (WFP) completed an assessment of the two key systems i.e. P-PAS and SCMS and published a report with recommendations for enhancements to these systems. Figure 2, describes the automation systems that have been developed to automate the entire value chain in Odisha.

[3] http://dfpd.nic.in/decentralized-procurement.htm

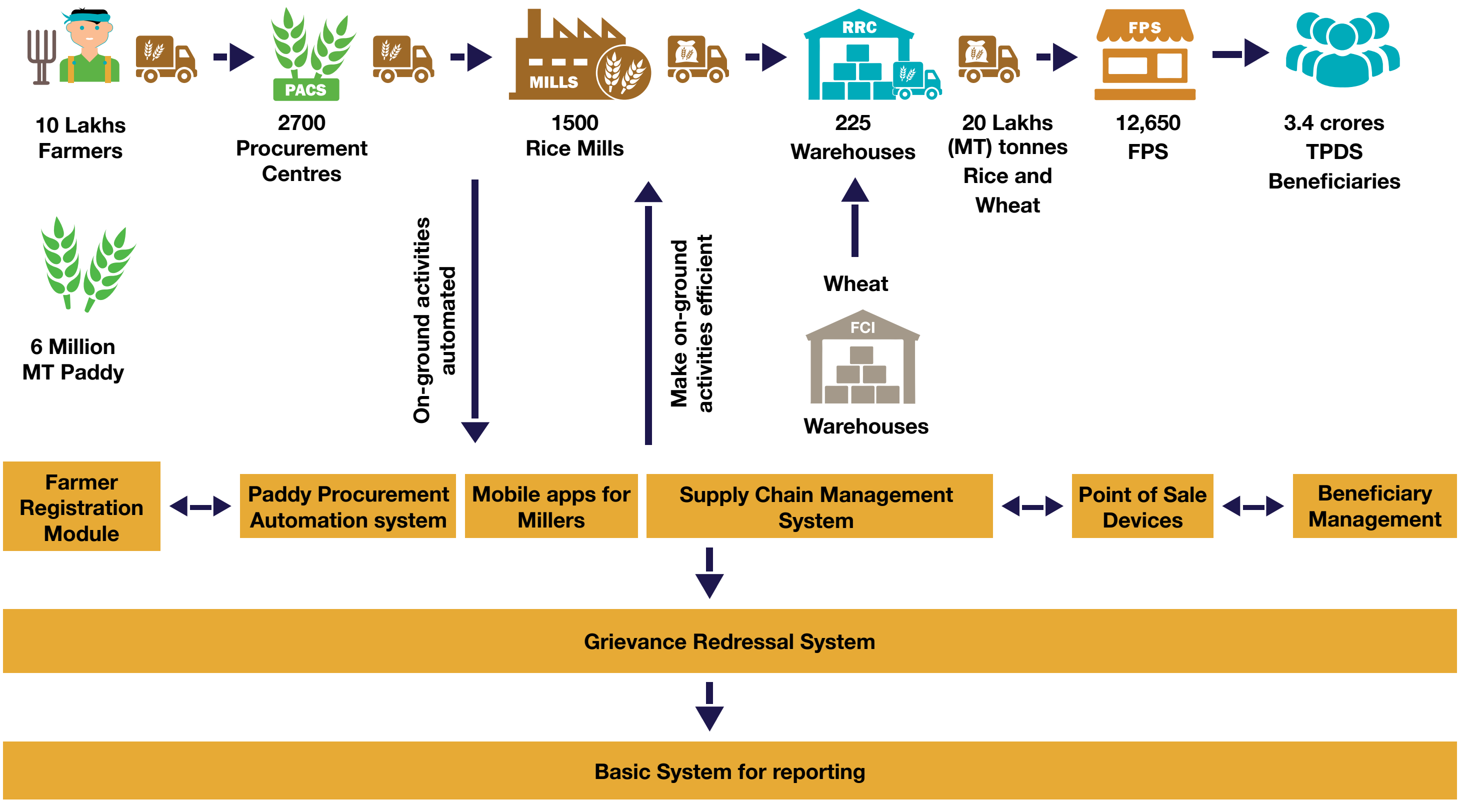


Figure 2: Status of automation in the entire supply chain of Odisha **(All numbers mentioned above are approx.)**

The core recommendations of the April mission included a comprehensive business process review of the SCMS and P-PAS system to enhance and integrate the two systems. The report also suggested stringent measures to improve quality control, introduction of requisite infrastructure at PACS, introduction and adherence to Good Manufacturing Practices (GMP) at mills and improvement in warehouse management at RRCs to optimise the entire network was also recommended.

Following up on the recommendation of the assessment from April 2017 and on the request of the Government of Odisha(GoO), a Supply Chain Optimisation (SCO) mission to Odisha took place in December 2017 to study optimisation opportunities from an operational research perspective in the supply chain for TPDS in Odisha.

2.1. KEY OBJECTIVES

Based on the SCO scoping mission in December and in consultation with the government it was proposed to undertake a Proof of Concept (PoC) to identify the optimal network tagging for the supply chain network of the TPDS system for one district. The PoC was established by applying WFP's optimisation approach and tools, leading to efficiency gains in the delivery of food grains and realisation of potential savings. Odisha's Dhenkanal district, which has 9,28,884 TPDS beneficiaries and a total demand of 45,000 Qtls. of rice per month, was chosen for this assessment because of good data availability on account of an unrelated supply chain mapping exercise that was performed for this district.

The main goal of the SCO mission was to showcase that savings in comparison to the 'as-is' scenario, which can be achieved within an individual district. Since the supply chain setup in other districts is similar, it is very likely that these savings can then also be achieved in the other districts with similar supply chain setup.

The key objectives for the SCO mission were as below:

1. **Mapping optimal network tagging and flow from PACS to FPS** – Propose alternative and more efficient network allocation/tagging scenarios between different nodes of the supply chain (i.e. PACS to Mill, Mill to RRC etc.).
2. **Clustering final delivery nodes by "Supply Zone" (and not by administrative block)** – Suggest a new clustering of FPSs by supply zone (following the optimal allocation and not the geographical block structure) so that transportation in leg 3 i.e RRC to FPS can be optimised.
3. Estimate the potential/quantum of savings feasible under various scenarios.
4. Verify the feasibility of results on ground.

2.2. APPROACH AND METHODOLOGY

The initial scoping mission in December was completed to conduct interviews with key stakeholders, visit field operations and to collect and screen documents and data. The data and information collected was further analysed to identify and prioritise potential areas of optimisation. The scoping mission also accessed feasibility, potential next steps and charted a roadmap for project implementation. An initial assessment of Dhenkanal district which was identified for the PoC was completed and showed that:

- Data was captured and available for all nodes of the supply chain.
- Supply chain network was sufficiently complex and based on 'greedy algorithms' to merit the use of optimisation software to support planning.
- There were opportunities to apply optimisation algorithms to existing data to identify a more efficient and cost-effective supply chain network.

An initial mapping of the supply chain for Dhenkanal is as presented below:

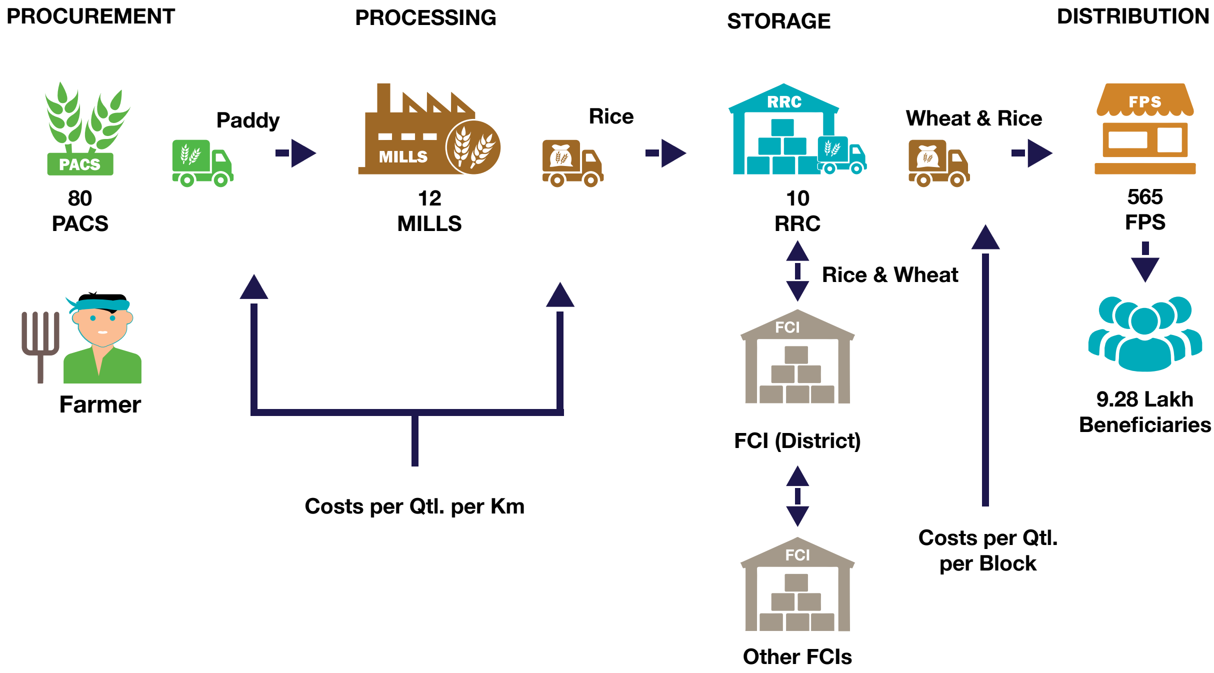


Figure 3: Mapping of the supply chain for Dhenkenal

Immediate opportunities to apply optimisation were identified that could lead to significant gains/savings in Odisha's TPDS supply chain. Further, the team defined a range of scenarios (refer to Section 2.5 for details), each focused on changing one part at a time and then adding more parts (e.g. FPS tagging). The more elements of the supply chain the optimiser could change, the bigger were the resulting efficiency gains. But considering that not all parts of the supply chain are easy to redesign in practice, various scenarios were created to ensure that not many changes are made to the exsiting operations. This report presents the results and observations from all identified scenarios in comparison to the 'as-is' baseline scenario.

2.3. DATA SOURCES

The following data sets provided by GoO were used for the analysis. The data is from 2016-2017 distribution, either monthly or yearly depending on the nature of data.

Data	Data Description
PACS Tagging	Tagging between PACS to mills
FPS Tagging	RRC to FPS distance and allocation of each FPS
Procured Paddy Volume	Dhenkanal procurement data for 2016
Distributed Rice Volume	Allotment reports for FPS by block for Dec 2017
Rice Volume Transported (Mill-RRC)	Data for transportation of Kharif season 2016-17 for Dhenkanal
Distances (PACS - Mill)	Distance between PACS and mills

Data	Data Description
Distances (Mill - RRC)	Distance between mills and RRCs
Distances (RRC - FPS)	Distance between RRCs and FPSs
Distances (FCI - RRC)	Distance between FCI warehouse and RRCs
Transport rates (PACS – Mill / Mill - RRC)	Transportation rates for PACS to mills and mills to RRCs
Transport rates (RRC - FPS)	Transportation rates for RRCs to FPSs
PACS locations and capacities	Latitude, longitude and capacity details of PACS
Mill locations	Latitude and longitude of the mills
Mill capacities	Mill allocation and capacity details
RRC locations	Latitude and longitude of RRCs in Dhenkanal
RRC capacities	Storage capacity of RRCs in Qtls.
FPS locations	Latitude and longitude details for FPSs

Table 3: Input fields and their description

The below tables provide the current transportation rates for all the leg i.e. PACS to Mill, Mill to RRC and RRC to FPS.

The prices of transport from PACS to Mill and Mill to RRC are defined per Qtl. per Km and the prices for transport between RRC to FPS is defined per Qtl. and depends upon the block of the FPS. Below are the rates in the current scenario.

Origin	Destination	0-10 Km.*	10-30 Km.**	30 Km. and above
PACS	Mill	₹ 18	₹ 0.50	₹ 0.40
Mill	RRC	₹ 15	₹ 0.50	₹ 0.40

**Fixed rate for the first ten Km.*　　***Rates are per Qtl. per Km.*

Block Name	Cost *
Bhuban NAC	₹ 32.69
Dhenkanal MPL	₹ 25.96
Parjang	₹ 29.97
Dhenkanal Sadar	₹ 35.64
Parjang	₹ 38.56
Kankadahad	₹ 35.44
Hindol	₹ 32.12
Odapada	₹ 47.18
Gondia	₹ 47.63
Bhuban	₹ 32.69
Kankadahad	₹ 34.38
Kamakhyanagar NAC	₹ 31.49
Kamakhyanagar	₹ 31.49

**Rates are per Qtl. by block*

Table 4: Current cost of transportation

2.4. OPTIMISATION MODEL

The optimisation model for the TDPS supply chain network is conceptualised as a capacitated multi-commodity network flow, defined using a mixed integer linear program, and solved using the COIN-OR symphony solver. The mathematical model used to capture the end-to-end supply chain from PACS to FPS was designed to minimise the total transportation costs of the entire value chain. The necessary data was inserted through an excel file. This excel file was imported and converted into a mathematical model.

This method ensured that it would be easy to re-run the model in case the data changed and that it would also be possible to run the same model for a different district if the data is available in a structured format. Depending on the scenario, a (slightly) different mathematical optimisation model was solved to identify the optimal solution for the corresponding scenario.

- A solution consists of the allocation of volume (rice, wheat and paddy) that should travel between all locations (e.g. PACS to Mill, RRC to FPS, etc.) to minimise the total transportation costs.
- The script further generates three different outputs for the specific scenario:
    - A table containing the **Key Performance Indicators (KPIs)** such as transportation cost, average costs and average distance travelled for all the legs in the supply chain network.
    - A file containing the details of the cost or transportation, distance and volume of commodity (rice/wheat/paddy) travelled between each node (e.g. between each mill to each RRC) of the supply chain network.
    - Maps that visualise the supply chain network and the tagging of various locations (e.g. RRC to FPS) using geocodes.

2.5. SCENARIOS

The table below describes the various scenarios that were executed and for which results have been compared.

S.No	Scenario Name	Description
1	Baseline or 'As is'	Model the existing network to calculate costs and prepare a base for comparison with other scenarios.
2	Baseline with change in transport payment modality	Investigate potential savings with change in transporter payment modality from per Qtl. to per Qtl. per Km.
3	Optimising PACS Tagging	Investigate potential savings by only changing the PACS to Mill tagging (assuming mill throughput is kept equal).
4	Optimising leg 1 & 2	Investigate potential savings by changing the PACS to Mill and Mill to RRC tagging (assuming mill throughput can change as well).
5	Optimising FPS Tagging	Investigate potential savings by only changing the RRC to FPS tagging.
6	Closing Mills	Investigate potential saving by closing a few mills and changing tagging from PACS to Mill and Mill to RRC.
7	Closing PACS	Investigate potential saving by closing a few PACS and changing tagging from PACS to Mill.
8	Closing FPS	Investigate potential saving by closing a few small FPS (<35 Qtl.) and shift their demand to another FPS that is close by (within 2 Km.) and investigate the effect on the transportation costs.
9	Optimised (same cap.)	Investigate potential savings in the transportation cost by assuming that the throughput of all locations (RRCs and mills) remains the same.
10	Optimised (cap +15%)	Investigate potential savings by assuming that each location in the network (mills and RRCs) can handle up to 15% more than the current throughput.
11	Fully Optimised	Investigate potential savings if the optimiser allows the throughput of every location in the network to change (mills should not exceed capacity).

Table 5: Scenarios and their description

2.6. KEY OUTPUTS AND OUTCOMES

For each scenario the model generates three different output files as described in section 2.4. First, the model generates a summary table that contains the KPIs, which can be used to compare different scenarios without delving too much into the details of the solution. The KPI's are detailed as below:

KPI:	Unit:	Description:
1. Total Transportation Costs:	Rs.	The total costs that are incurred for transportation. Calculated separately for the transport of paddy, rice and wheat and for every transportation leg.
2. Average Transportation Costs:	Rs. / Km. / Qtl.	The average transportation costs are calculated per Km. per Qtl. This allows a comparison of costs incurred in the different transportation legs.
3. Average Distance Travelled[4]:	Km./Qtl.	This KPI indicates the average distance that each Qtl. of grain has to travel to get from its origin to its destination in the corresponding transportation leg.

Table 6: Key output KPI's and their description

Secondly, the model generates an excel file that contains details for every location and supply chain leg in the optimised configuration of the network for every scenario segregated by type of commodity (refer table 7 on next page). For each movement the optimiser captures the origin and destination locations, the volume transported, commodity type, distance travelled, and the average and total transportation costs that are incurred. This file can be used to analyse the optimal network configuration in more detail and to aggregate the results. Finally, for every leg in the transportation network, the model generates maps that help visualise the supply chain network and the tagging of various locations (e.g. RRC – FPS) using geocodes (refer figure 4).

PACS-MILL
Baseline

Figure 4: Sample output map of PACS to Mills in baseline

These results can be used to gain valuable insights on how to achieve savings on transportation cost. Insights from various scenarios could inform a policy, operational or technical change in the supply chain configuration. Below are some of outputs from the models which can inform operational, technical or policy level changes.

TAGGING AND DISTANCE

- Tagging of PACS to Mill and Mill to RRC.
- Tagging between FCI to RRC and RRC to FPS.
- Distance travelled between PACS to Mill, Mill to RRC, FCI to RRC and from RRC to FPS.

VOLUME

- Volume of paddy supplied between each PACS and mill.
- Volume of rice supplied by each mill to each RRC and wheat from FCI to each RRC.
- Volume from each RRC to each FPS without any change in the total allocation for each FPS.

COSTS

- Ideal transport rate which should be negotiated for the RRC to FPS transport leg.

[4] Distance travelled for wheat to reach FCI godowns in Odisha is not included

Leg	Origin	Destination	Commodity	Block	Ori_lat	Ori_long
PACS-MILL	S1090506	NATURAL AGRITECH PVT LTD	PADDY	KAMAKHYANAGAR	20.912028	85.518111
PACS-MILL	S1090702	NATURAL AGRITECH PVT LTD	PADDY	ODAPADA	20.706722	85.510806
PACS-MILL	S1090210	BDN FOOD PRODUCTS	PADDY	DHENKANAL	20.571472	85.63125
PACS-MILL	S1090307	BDN FOOD PRODUCTS	PADDY	GANDIA	20.786444	85.7225
PACS-MILL	S1090310	BDN FOOD PRODUCTS	PADDY	GANDIA	20.846	85.856028
PACS-MILL	S1090312	BDN FOOD PRODUCTS	PADDY	GANDIA	20.850306	85.748278
PACS-MILL	S1090306	BDN FOOD PRODUCTS	PADDY	GANDIA	20.741111	85.783667
PACS-MILL	S1090201	BDN FOOD PRODUCTS	PADDY	DHENKANAL	20.725806	85.60075
PACS-MILL	S1090208	BDN FOOD PRODUCTS	PADDY	DHENKAMAL	20.786083	85.636528
PACS-MILL	S1090314	BDN FOOD PRODUCTS	PADDY	GANDIA	20.796972	85.992417
PACS-MILL	S1090801	BHUTIA FOOD PVT LTD	PADDY	PARAJANG	20.942389	85.417167
PACS-MILL	S1090303	HARAPRIYA RICE MILL	PADDY	GANDIA	20.790278	85.761
PACS-MILL	S1090303	BDN FOOD PRODUCTS	PADDY	GANDIA	20.790278	85.761
PACS-MILL	S1090202	BDN FOOD PRODUCTS	PADDY	DHENKANAL	20.618278	85.642472
PACS-MILL	S1090303	NATUAL AGRITECH PVT LTD	PADDY	GANDIA	20.790278	85.761

Table 7: Sample output -excel file PACS to Mills in baseline

2.7. LIMITATIONS OF THE MODEL AND ANALYSIS

This PoC focused on mapping the supply chain network and analysing the grain flow between various locations, however even while it provides details of the tagging, volume, distance and costs of transportation between various legs, there are a few limitations to this model, which are detailed as below:

1. The model does not consider the time dimension (e.g. months, weeks) and therefore it cannot be used to answer questions that relate to time (e.g. when to purchase paddy at PACS; how long to store rice at RRCs; when to dispatch a truck from Mill to RRC).
2. The model focuses exclusively on minimising transport costs, so it does not account for costs related to processing at RRCs i.e. storage, loading and unloading costs, etc., since they increase or decrease depending on the change in volume.
3. The PoC focused on a single district, which means the current model does not look at inter-district flows (e.g. sending surplus rice to an FCI, supplying an FPS from a RRC in a different district, etc.) hence:
    - Absolute savings that can be achieved through optimisation is not very large.
    - Efficiency gains by dropping the administrative boundaries of the district itself could not be defined i.e. more efficiencies can be realised once the entire supply chain is optimised.

Note: For future applications these limitations can be addressed by improving the model, assuming the required data is made available.

Des_lat	Des_long	Distance	Qtal_costs	Volume	Leg_costs	Scenario	Vol*dist	Avg cost
20.821222	85.542556	13.05	19.525	48.803565	952.8896066	BASELINE	636.8865233	1.4961686
20.821222	85.542556	18.14	22.07	55.930196	1234.379426	BASELINE	1014.573755	1.2166483
20.699556	85.618111	17.25	21.625	62.367423	1348.695522	BASELINE	1075.838047	1.2536232
20.699556	85.618111	19.51	22.755	66.698136	1517.716085	BASELINE	1301.280633	1.166325
20.699556	85.618111	37.23	31.615	67.074871	2120.572047	BASELINE	2497.197447	0.8491808
20.699556	85.618111	27.98	26.99	69.52748	1876.546685	BASELINE	1945.37889	0.9646176
20.699556	85.618111	23.33	24.665	113.94602	2810.498583	BASELINE	2658.360647	1.0572225
20.699556	85.618111	4.54	8.172	133.18597	1088.395747	BASELINE	604.6643038	1.8
20.699556	85.618111	13.37	19.685	138.72836	2730.867767	BASELINE	1854.798173	1.4723261
20.699556	85.618111	49.09	36.636	139.29223	5102.377418	BASELINE	6836.873771	0.7463027
21.00975	85.293278	20.55	23.275	144.05836	3352.958329	BASELINE	2960.399298	1.1326034
20.601139	85.515944	39.7	32.85	165.32893	5431.055351	BASELINE	6563.558521	0.8274559
20.699556	85.618111	25.18	25.59	168.2286	4304.969874	BASELINE	4235.996148	1.0162828
20.699556	85.618111	24.82	25.41	169.31355	4302.257306	BASELINE	4202.362311	1.0237712
20.821222	85.542556	39.71	32.855	188.2659	6185.476145	BASELINE	7476.038889	0.8273735

BASELINE

3

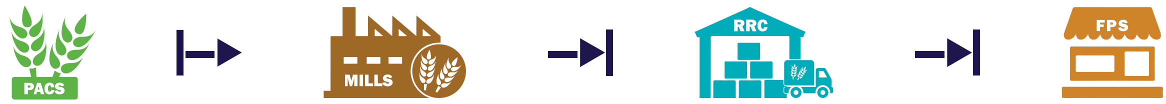
CHAPTER

BASELINE

3.1. ABOUT THE SCENARIO

The main purpose of this scenario is to model the current configuration of the procurement and distribution network of Dhenkanal district and quantify the exsiting tagging, volumes and cost of transportation. The baseline is vital to validate model assumptions, inputs, and outputs, and enable comparison of other optimised scenarios against the performance of the current supply chain setup. The outputs under this scenario have been generated based on actual data from the existing supply chain setup.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl.

Can be changed   Remains the same   Can be closed

Table 8: Key statistics for the baseline

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

Furthermore, this scenario has also been used to calculate the estimated transport rate (per Qtl. Per Km.) for the last leg (RRC-FPS) based on the existing cost of transportation, which is paid out to the transporters. The estimated cost is then further used to show potential savings in other scenarios. Please find below the table described the cost calculations.

RRC → LEG → FPS

Total Transportation Costs (Rs. /month) (A)	Sum of Volume*Distance (Rs. /Qtl. /km) (B)	Average Cost (Rs. /Qtl./ Km) (C=A/B)
Rs. 19,34,274.29	Rs. 11,85,592.69	Rs. 1.63

Table 9: Calculation of estimated current transport rate per Qtl. per Km.

3.2. KEY CONSTRIANTS

1. Every PACS can only supply a mill that it's connected to according to the current PACS tagging.
2. All paddy that is procured is transported to one of the mills in the district.
3. All paddy that is procured from the PACS is processed by the mills.
4. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
5. The volumes of rice that are being transported from mills to RRCs are given by the data.
6. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
7. FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
8. All demand for rice and wheat at every FPS must be satisfied.
9. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
10. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
11. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

[5] Values are rounded off to maximum two decimal places, hence there may be slight differences in computed transportation costs as compared to the values provided.

3.3. SUMMARY STATISTICS

Parameters:	Number of PACS	Quantity Procured at PACS (Paddy)	Number of Mills	Output Quantity of Mills (Rice)	Number of RRCs (Wheat)	Quantity Stored at RRC (Wheat)
Baseline:	80	73,529 Qtls.	12	50,000 Qtls.	10	8000 Qtls.

Parameters:	Number of RRCs (Rice)	Quantity Stored at RRC (Rice)	Number of FPS (Rice)	Quantity Delivered at FPS (Rice)	Number of FPS (Wheat)	Quantity Delivered at FPS (Wheat)
Baseline:	10	50,000 Qtls.	565	45000 Qtls.	565	8000 Qtls.

Table 10: Summary statistics for the baseline

3.4. KEY PERFORMANCE INDICATORS

Leg		Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)	**Baseline**	15,69,794 (34%)	1.09	19.51
MILLS → RRC: Rice (45,000 Qtls)	**Baseline**	9,09,631 (20%)	0.95	19.24
RRC → FPS: Rice (45,000 Qtls)	**Baseline**	16,44,524 (36%)	1.63	22.40
FCI → RRC: Wheat (8000 Qtls.)	**Baseline**	1,57,941 (4%)	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)	**Baseline**	2,89,750 (6%)	1.63	22.22

Table 11: Key outputs for the baseline

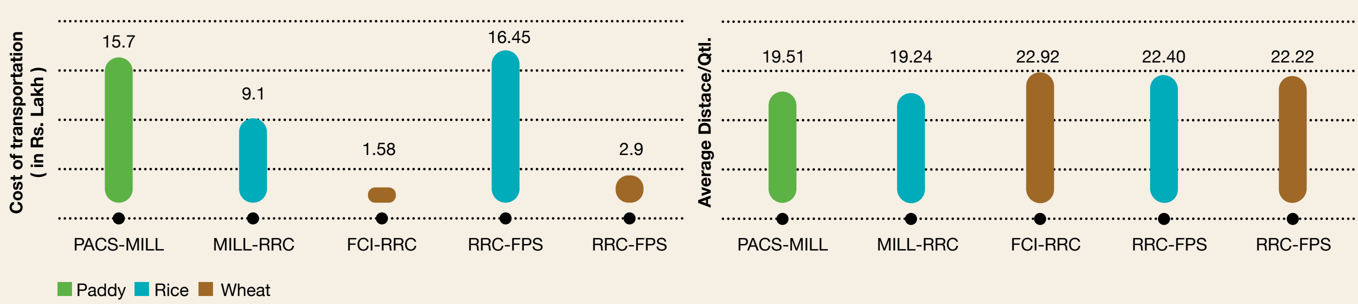


Figure 5: Total distance and cost of transportation by leg for the baseline [5]

The figure 5, shows the breakup of transportation costs per leg in comparison to the average distance travelled per Qtl. For Leg 1, 2, 3, the costs are derived per Qtl. per Km. and for Leg 4 the costs are by Qtl., but restricted to a block. As can be observed, maximum cost is incurred in Leg 4 followed by Leg 1.

3.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

3.4.1.1. TAGGING AND VOLUME

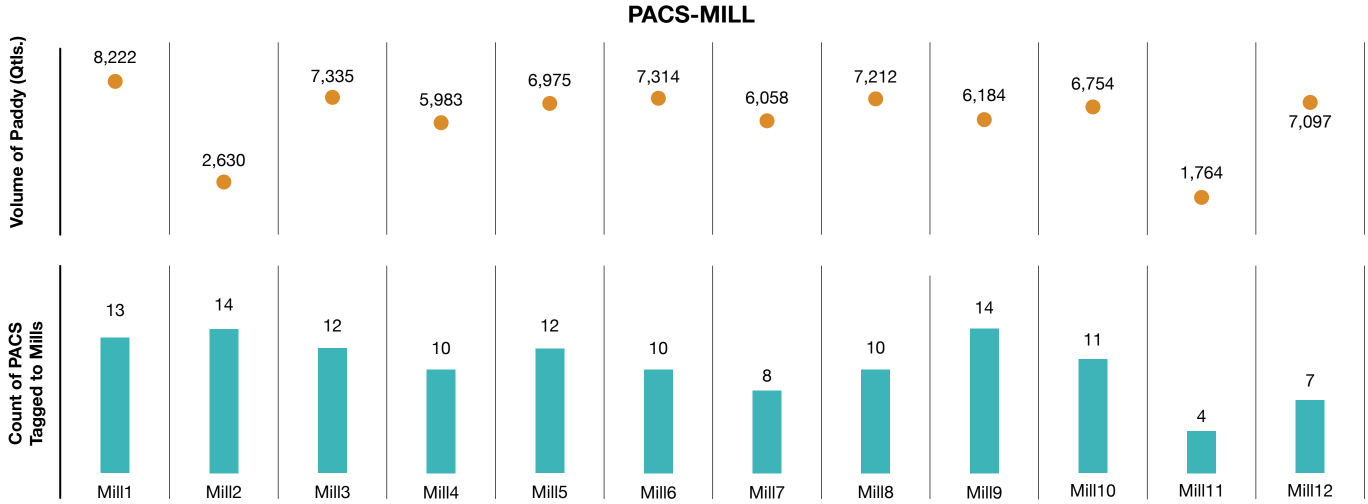


Figure 6: Tagging and volume from PACS to mills in baseline

- There are 80 PACS and 12 mills, while the nodes traversed are 125, which shows that many PACS are attached to each mill or vice versa (Figure 6).
- Even through there are 14 PACS tagged to Mill2 (BDN Food Products) the total paddy allocated to the mill is amongst the lowest in the district.
- Milling allocation is evenly distributed and all mills, except Mill 2 and Mill 11 have an average allocation of ~6500 Qtls.

3.4.1.2. DISTANCE AND COSTS

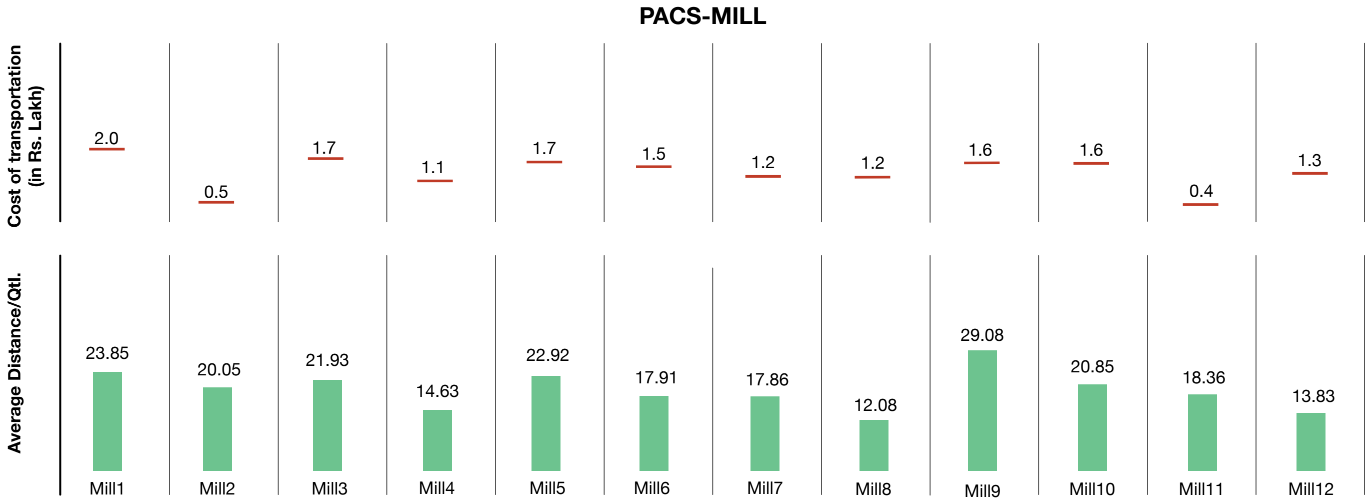


Figure 7: Distance and cost of transportation from PACS to Mill in baseline

- The cost of transportation in Leg 1 and the average distance/Qtl travelled from PACS to Mill is described in figure 7. As can be observed, the average distance/Qtl travelled between PACS and Mill 2 (BDN Food Products) is above average (i.e 19.4), but the cost of transportation is amongst the lowest.

- In line with the above observation, figure 8 describes the volume and cost of transportation for Mill 1(Annapurna Rice Mill), which has the highest cost of transportation and Mill 2 (BDN Food Products), which has one of the least costs of transportation. The results indicate that the cost of transporting paddy in distance range of 0-10 km is much lower than in any other distance range. For Mill 2 (BDN Food Products), 46% of the paddy is being delivered by PACS within 0-10 km distance range while incurring only 23% of the costs. This indicates a potential to maximise tagging within this distance range to minimise costs.

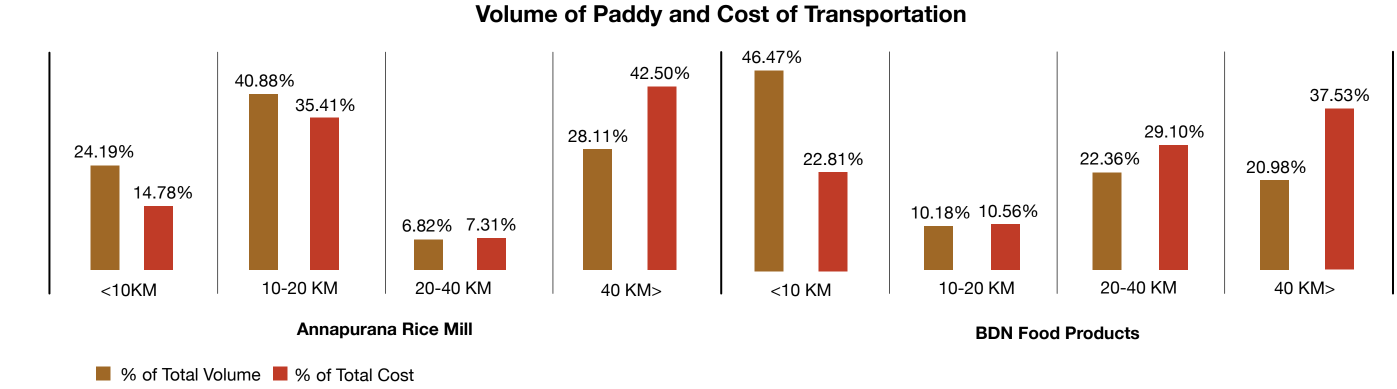


Figure 8: Volume and cost of transportation of paddy over distance range in baseline

3.4.2. OBSERVATIONS FOR LEG 2: MILL TO RRC, FCI TO RRC

3.4.2.1. TAGGING AND VOLUME

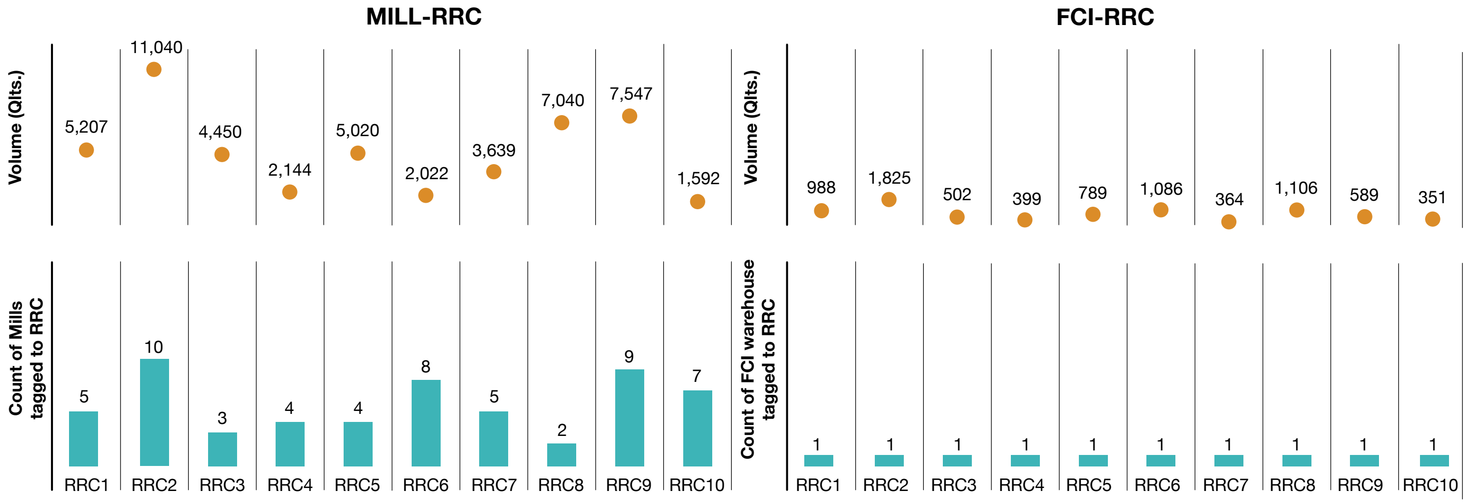


Figure 9: Tagging and volume of rice and wheat from mills and FCI respectively to RRC in baseline

- Total number of mills is 12, which are tagged to 10 RRCs, but the total number of nodes traversed from mills to RRC is 57 (Figure 9).
- Wheat is supplied from FCI Dhenkanal to all the 10 RRCs and hence the tagging is one to one.
- Figure 9, also represents the volume of rice from mills to each RRC. It can be observed that even though RRC 6 (Dhenkanal) and RRC10 (Mahispat (II)) are tagged to 8 and 7 mills respectively, the handled volume is amongst the lowest in the district.

3.4.2.2. DISTANCE AND COSTS

- Figure 10, describes the cost of transportation and average distance/Qtl between mills and RRCs and FCI to RRC.
- The distance for RRC 6 (Dhenkanal) in the FCI to RRC leg is zero because RRC 6 and FCI Dhenkanal located in the same place.

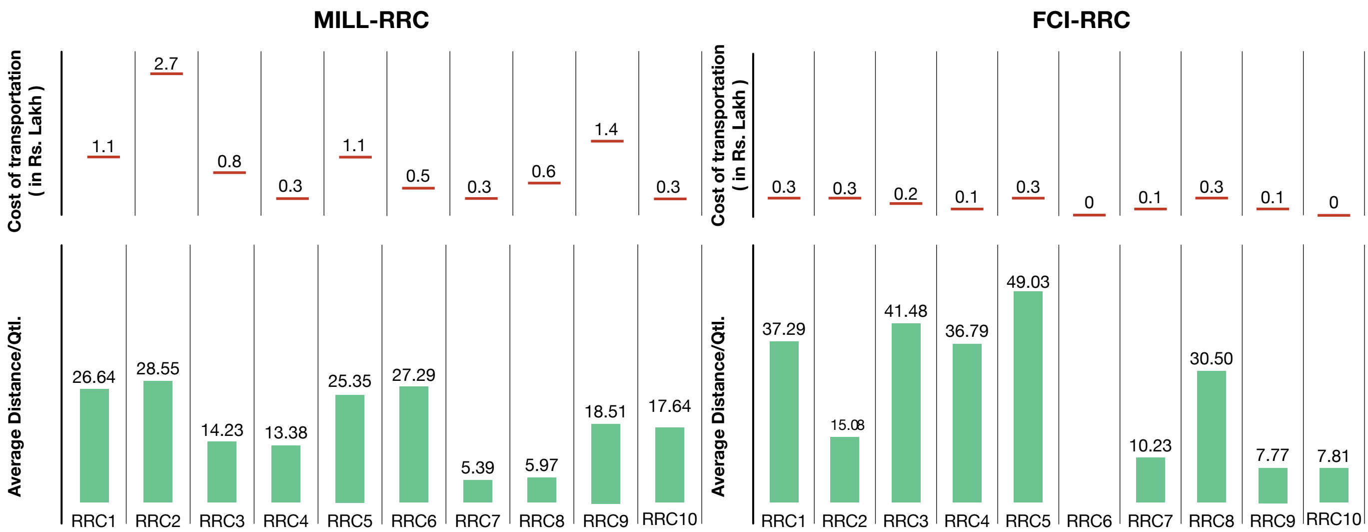


Figure 10: Distance and cost of transportation from mills to RRCs and FCI to RRC in baseline

RRC 2 and 9 i.e. Baladiabandha and Mahispat (I) handle one of the highest volume of rice from mills (11,040 and 7040 Qtls. respectively) and the distance travelled between Mill to RRC is also the highest as can be seen. in figure 11, hence the cost of transportation is the highest for these RRC's in the Mill to RRC leg.

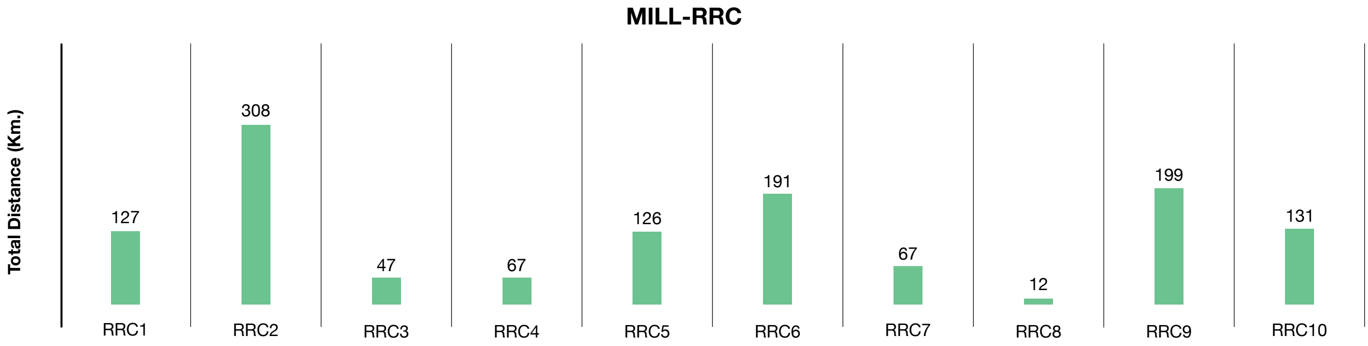


Figure 11: Total Distance from Mills to RRC in baseline

3.4.3. OBSERVATIONS FOR LEG 3: RRC TO FPS

3.4.3.1. TAGGING AND VOLUME

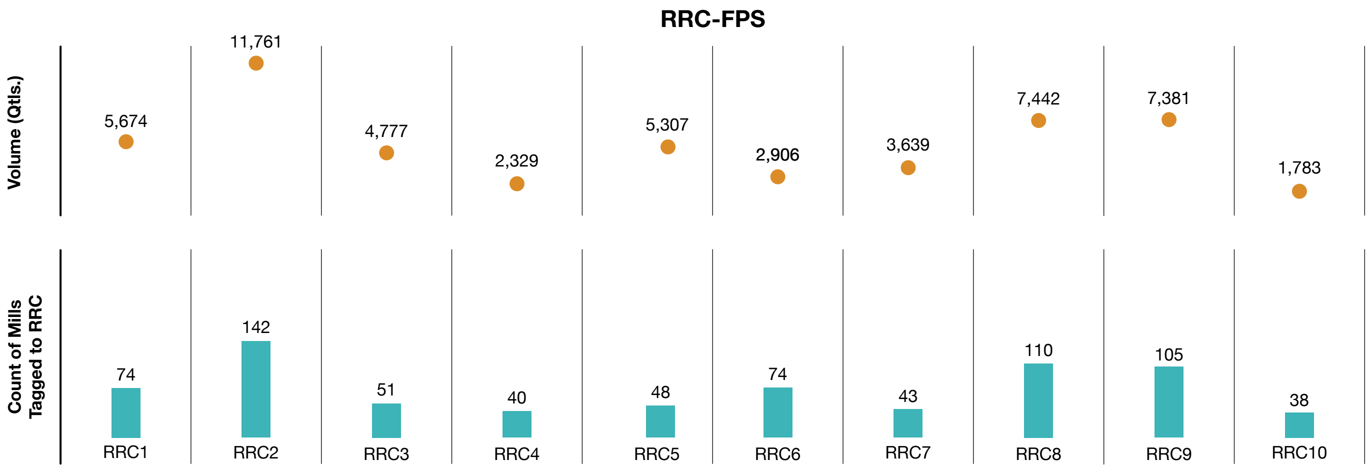


Figure 12: Tagging and volume of rice and wheat from RRC to FPS in baseline

The tagging and volume (rice and wheat) from RRCs to FPS in the baseline is represented in figure 12. The volume of food grains is dependent on the demand of the tagged FPS. The demand of each FPS is further dependent on the number of cards tagged to the FPS. As can be observed, RRC 2 (Baladiabandha) has the highest allocation and the most number of FPS tagged to it.

3.4.3.2. DISTANCE AND COSTS

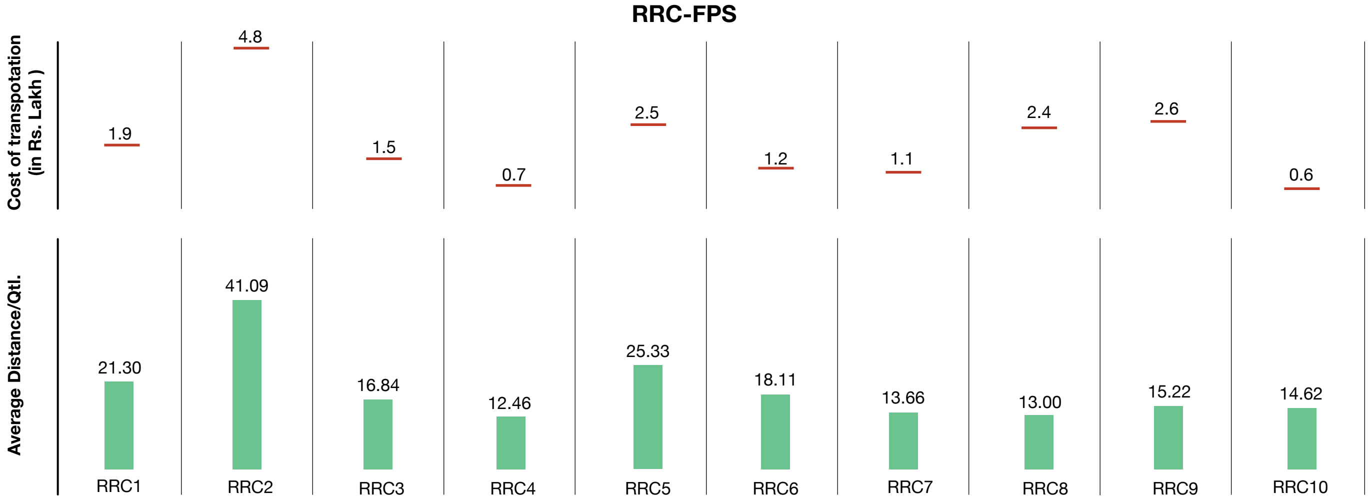
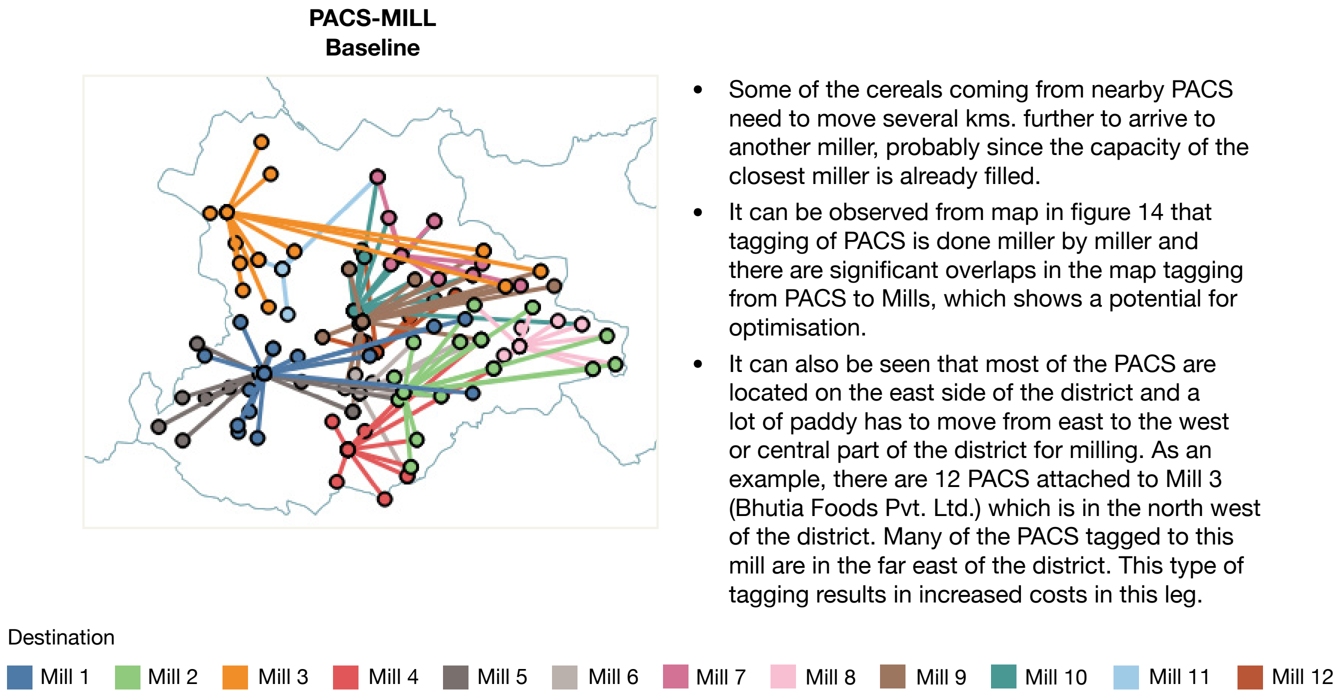


Figure 13: Distance and cost of transportation from RRC to FPS in baseline

Figure 13, describes the cost of transportation and distance travelled for delivering foodgrains from RRC to FPS. Cost of transportation is dependent only on the volume of foodgrains. s can be seen for RRC5 (Bhubhan) and RRC9 (Mahispat I), the average distance/Qtl. for paddy is much lower for RRC9 than RRC5, but since the volume of foodgrains at RRC9 is higher, the cost of transportation is also higher for RRC9.

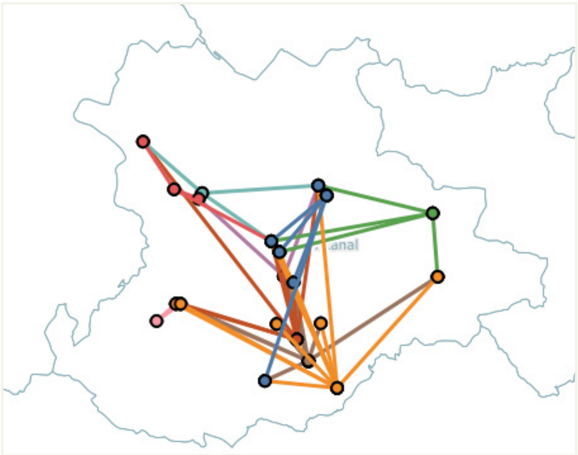
3.4.4. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN BASELINE



- Some of the cereals coming from nearby PACS need to move several kms. further to arrive to another miller, probably since the capacity of the closest miller is already filled.
- It can be observed from map in figure 14 that tagging of PACS is done miller by miller and there are significant overlaps in the map tagging from PACS to Mills, which shows a potential for optimisation.
- It can also be seen that most of the PACS are located on the east side of the district and a lot of paddy has to move from east to the west or central part of the district for milling. As an example, there are 12 PACS attached to Mill 3 (Bhutia Foods Pvt. Ltd.) which is in the north west of the district. Many of the PACS tagged to this mill are in the far east of the district. This type of tagging results in increased costs in this leg.

Figure 14: Geo-representation of tagging from PACS to Mill in baseline

MILL-RRC
Baseline



FCI-RRC
Baseline

Destination

RRC 1 | RRC 2 | RRC 3 | RRC 4 | RRC 5 | RRC 6 | RRC 7 | RRC 8 | RRC 9 | RRC 10

Figure 15: Geo-representation of tagging from Mill to RRC in baseline

Map shown in figure 15, describes the tagging between mills and RRCs. The tagging does not seem to follow the proximity approach. As an example, there are 10 mills attached to RRC 2 (Baladiabandha). These mills are much closer to other RRCs than RRC 10 (Mahispat II), which highlights opportunities in the network planning.

Figure 16: Geo-representation of tagging from FCI to RRC in baseline

Map in figure 16 shows that the tagging from FCI to RRC is one to one and all RRC's are tagged to the FCI for procuring wheat.

RRC-FPS
Baseline

Figure 17, shows that RRCs in the south are even tagged to FPSs which are way up north. (Map is only representing movement of rice). As an example, RRC 2(Baladiabandha) which is in south of the district is tagged to FPSs in the extreme north, which could have been serviced by RRC 1 (Badasuanlo) and RRC 3 (Barihapur). Overall, tagging of RRCs to FPSs neither seems to follow a proximity approach nor block boundaries.

Origin

RRC 1 | RRC 2 | RRC 3 | RRC 4 | RRC 5 | RRC 6 | RRC 7 | RRC 8 | RRC 9 | RRC 10

Figure 17: Geo-representation of tagging from RRC to FPS in baseline

SCENARIO 1
BASELINE WITH CHANGE IN TRANSPORT CONTRACTING

CHAPTER 4

SCENARIO 1.
BASELINE WITH CHANGE IN TRANSPORT CONTRACTING

4.1. ABOUT THE SCENARIO

In this scenario, there is no variation from the baseline in terms of configuration of the transport network. The only variation from the baseline is the change in transportation contract modality for the last leg i.e. from RRC to FPS. As observed in the baseline, the transportation rate for the last leg i.e. RRC to FPS is based only on the volume and is calculated per Qtl., but in this scenario keeping all other parameters constant, transport costs in the last leg i.e. from RRC to FPS are computed using the cost per Qtl. /per Km. as in leg 2 i.e. Mill-RRC leg which is as below:

** Fixed rate for just 10 Km. ** Rates are for per Qtl. per Km.*

With no other change, if contract modality for transportation in the last leg is revised from per Qtl. to per Qtl. per Km., and the same rates as in the Mill to RRC leg are used, 19% cost savings can be achieved.

SCENARIO: BASELINE

SCENARIO: BASELINE WITH CHANGE IN TRANSPORT CONTRACTING

● *Can be changed* ● *Remains the same* ● *Can be closed*

Table 12: Key statistics for the scenario baseline with change in transport contracting

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

KEY CONSTRAINTS

1. Every PACS can only supply a Mill that it's connected to according to the current PACS tagging.
2. All paddy that is procured is transported to one of the mills in the district.
3. All paddy that is procured from the PACS is processed by the mills.
4. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
5. The volumes of rice that are being transported from mills to RRCs are given by the data.
6. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
7. FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
8. All demand for rice and wheat at every FPS must be satisfied.
9. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
10. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
11. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

4.2. KEY PERFORMANCE INDICATORS

		Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)	Baseline	15,69,794	1.09	19.51
	Baseline + CTC	15,69,794	1.09	19.51
MILLS → RRC: Rice (45,000 Qtls)	Baseline	9,09,631	0.95	19.24
	Baseline + CTC	9,09,631	0.95	19.24
RRC → FPS: Rice (45,000 Qtls)	Baseline	16,44,524	1.63	22.40
	Baseline + CTC	8,99,669 (-45%)	0.98 (-39%)	22.40
FCI → RRC: Wheat (8000 Qtls)	Baseline	1,57,941	0.86	22.92
	Baseline + CTC	1,57,941	0.86	22.92
RRC → FPS: Rice (8000 Qtls)	Baseline	2,89,750	1.63	22.22
	Baseline + CTC	1,58,945 (-45%)	1.01 (-38%)	22.22

(Baseline + CTC.) implies baseline with change in contract modality

Table 13: Key output KPI's for baseline with change in transport contracting

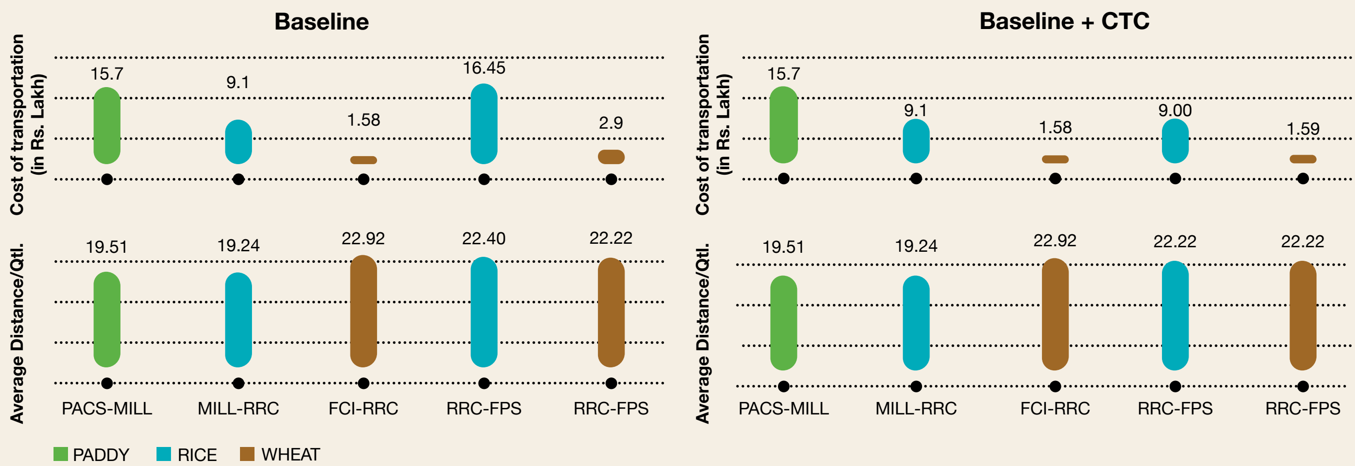


Figure 18: Total distance and cost of transportation by leg for the baseline with change in transport contracting

4.3. CHANGES FROM THE BASELINE TAGGING AND VOLUME

The total cost of transportation has reduced by 19% i.e Rs. 8,75,660 per month in the leg RRC to FPS. Based on analysis of results of the total distance travelled in this leg in the entire supply chain, it was observed that with a change in transportation contract modality i.e. by changing the contracting from cost per Qtl. to cost per Qtl. /Km., and using the rates as in the Mill to RRC leg, the overall costs are reduced by **approximately 19%**.

The supply chain tagging and flow for this scenario are the same as the one in baseline as there has been no change to the supply chain configuration.

4.4. CHANGES REQUIRED TO IMPLEMENT THIS SCENARIO

As there are no changes in the actual routes, clustering or network tagging of destinations, hence no technical and operational changes are proposed. Change in contracting will affect all block and L2 transporters in the state.

POLICY CHANGE

- Changes to the contract terms and conditions and new rate slabs for calculation of payments.
- Contracting of transport agents (L2 transporters) as per the changed contract modality.

SCENARIO 2
OPTIMISE PACS TAGGING

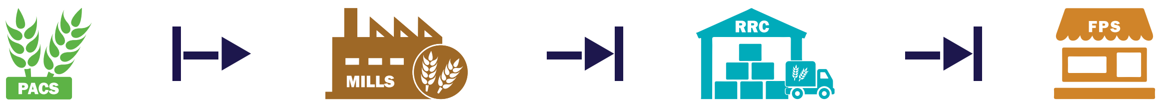
CHAPTER 5

SCENARIO 2.
OPTIMISE PACS TAGGING

5.1. ABOUT THE SCENARIO

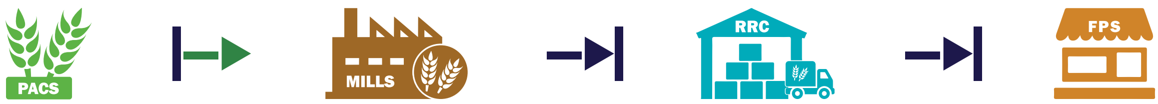
The purpose of this scenario is to investigate the quantum of savings that can be achieved by only changing the tagging between PACS and Mills. In this scenario, the volume of paddy assigned to PACS and mills remains the same and only changes are made to the tagging from PACS to Mills. Overall, by just changing the tagging between PACS to Mills, cost reduction of 2% of costs i.e Rs. 87,421 per month and 6% reduction in costs in leg 1 i.e from PACS to Mills can be achieved.

SCENARIO: BASELINE



TTC: RS. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: OPTIMISE PACS TAGGING



TTC: RS. 44,84,219 (-2%) | ADT: 82.5 KM./QTL. | ATC: 1.23 RS. PER KM./QTL.

● *Can be changed* ● *Remains the same* ● *Can be closed*

Table 14: Key statistics for optimising PACS tagging scenario

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

5.2. KEY CONSTRAINTS

1. All paddy that is procured is transported to one of the mills in the district.
2. All paddy that is procured from the PACS is processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. The volumes of rice that are being transported from mills to RRCs are given by the data.
5. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
6. FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
7. All demand for rice and wheat at every FPS must be satisfied.
8. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
9. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
10. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

5.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Optimise PACS Tagging	14,82,373 (-6%)	1.12 (+3%)	17.93 (-8%)
MILLS → RRC: Rice 45,000 Qtls			
Baseline	9,09,631	0.95	19.24
Optimise PACS Tagging	9,09,631	0.95	19.24
RRC → FPS: Rice 45,000 Qtls			
Baseline	16,44,524	1.63	22.40
Optimise PACS Tagging	16,44,524	1.63	22.40
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Optimise PACS Tagging	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Optimise PACS Tagging	2,89,750	1.63	22.22

Table 15: Key output KPI's for optimising PACS tagging scenario

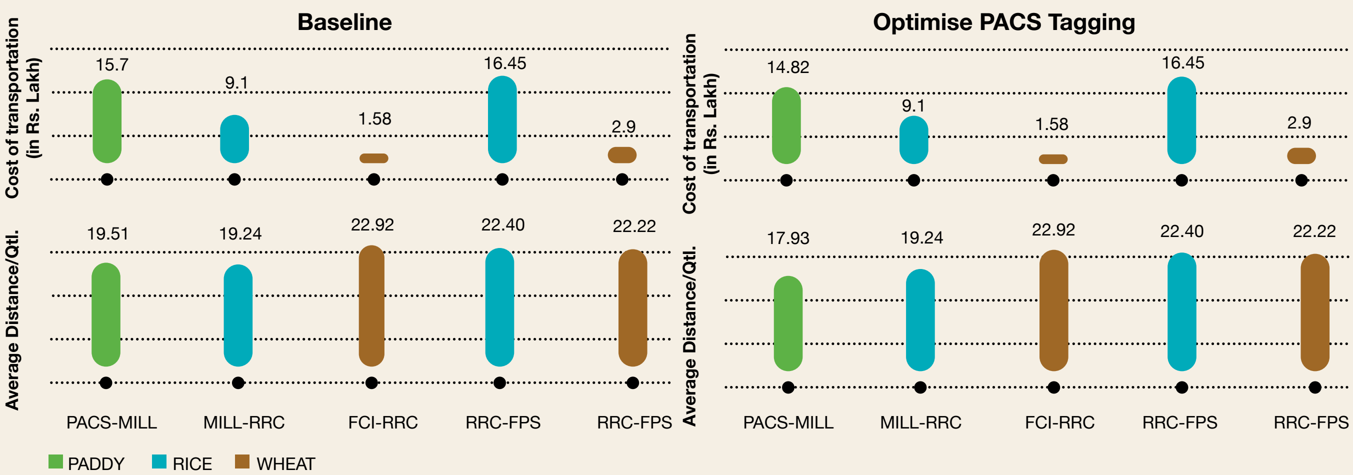


Figure 19: Distance and cost of transportation for all legs in the optimising PACS tagging scenario

Figure 19, describes the total cost of transportation and average distance/Qtl. travelled in each leg in the optimising PACS tagging scenario in comparison to the baseline. Since there are changes only to leg 1, the cost and average distance/Qtl. has been reduced only in Leg 1. As described in table 15, the average cost of transportation for leg 1 has shown a minor increase. This is largely because the average transportation costs are dependent on total transportation costs, volume and distance (i.e. average transportation costs = total cost of transportation/ (volume*distance) and while distance has reduced by 36% or 971.6 Km. due to changes in tagging, total cost of transportation in this leg has only reduced by 6%.

5.4. CHANGES FROM THE BASELINE

As the change in network configuration is only for leg 1 i.e. PACS to Mills, all the observations and outputs relate to this leg. Change is tagging of PACS to mills has led to reduction in the average distance travelled for each Qtl. of paddy from 19.51 Km. to 17.93 Km. Total cost savings in this scenario is 6% for leg 1 and 2% overall or Rs. 87,421 monthly.

5.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

5.4.1.1. TAGGING AND VOLUME

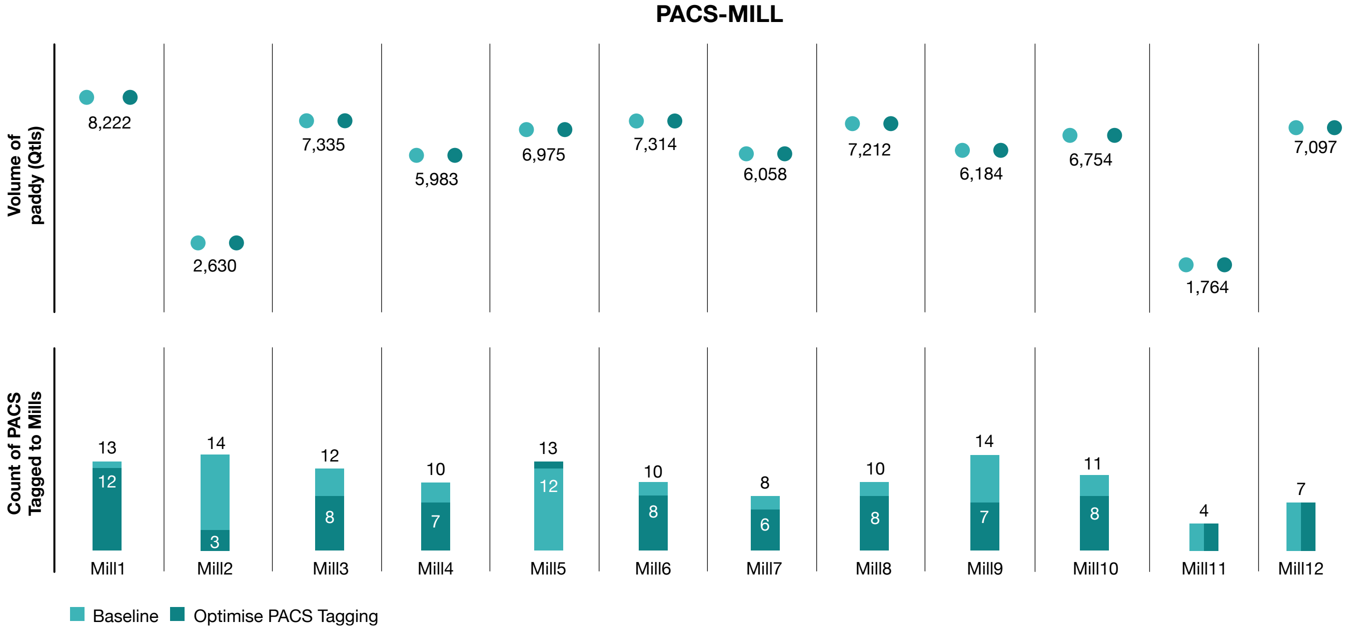


Figure 20: Tagging of PACS to Mill in the optimising PACS tagging scenario

- In this scenario, tagging for 52 out of 80 PACS has been changed. Total number of nodes traversed in leg 1 has changed from 125 to 91 (Figure 20).
- The number of PACS tagged to each mill has been either reduced or kept same (except for Mill 5). As an example, BDN Food Products (Mill2) which was tagged to 14 PACS in the baseline is tagged to 3 PACS in the optimising PACS tagging scenario.
- To ensure that there is no impact on the subsequent legs, a constraint was put in the model that allowed tagging of PACS to mills to change without any change in the total volume allotted to each mill. This means that even though there are changes in the volume delivered by each PACS to each mill, the overall quantity of paddy allocated to each mill remains the same. Figure 21 describes a few examples of the changes in the volume between tagged PACS and mills in this scenario as compared with the baseline.
- As can be seen in figure 21, the number of PACS tagged to mill 9 (Natural Agritech Pvt. Ltd.) has reduced from 14 to 7 and a few PACS that were never tagged to this mill have now been tagged to use mill in optimising PACS tagging scenario.

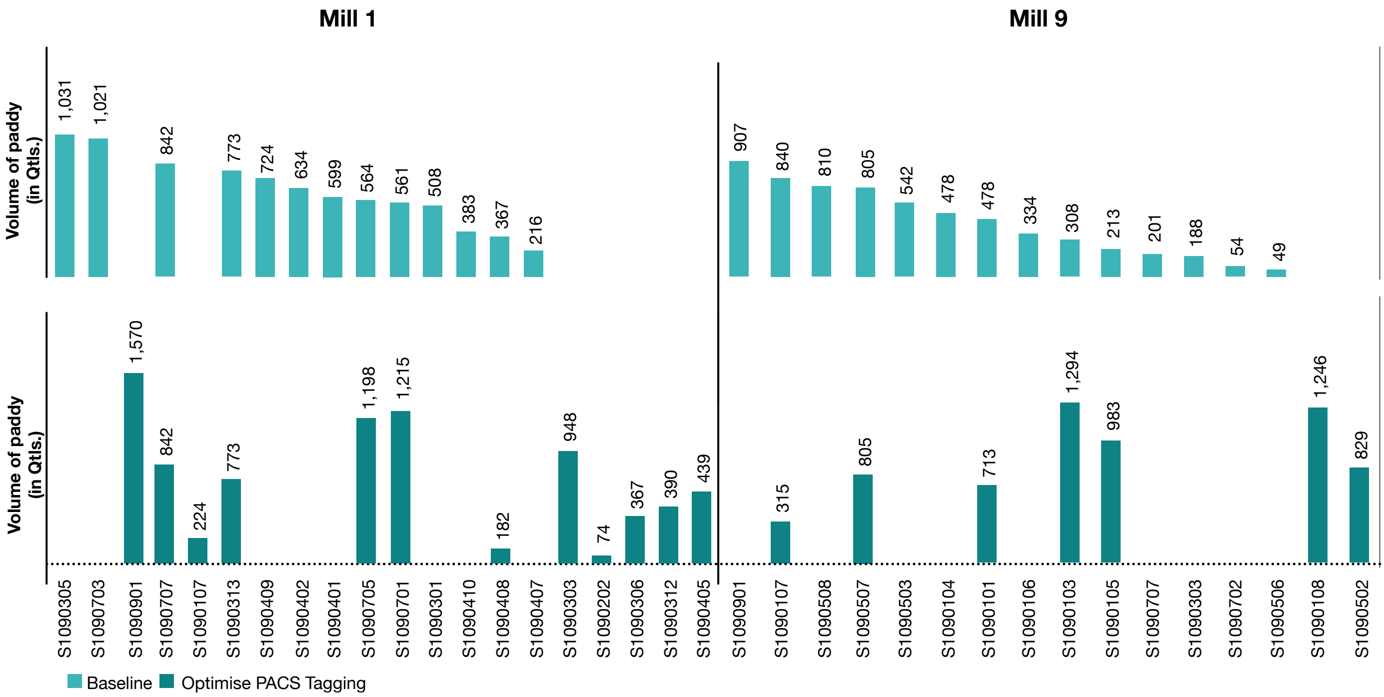


Figure 21: Volume of paddy from PACS to Mill in the optimising PACS tagging scenario

5.4.1.2. DISTANCE AND COSTS

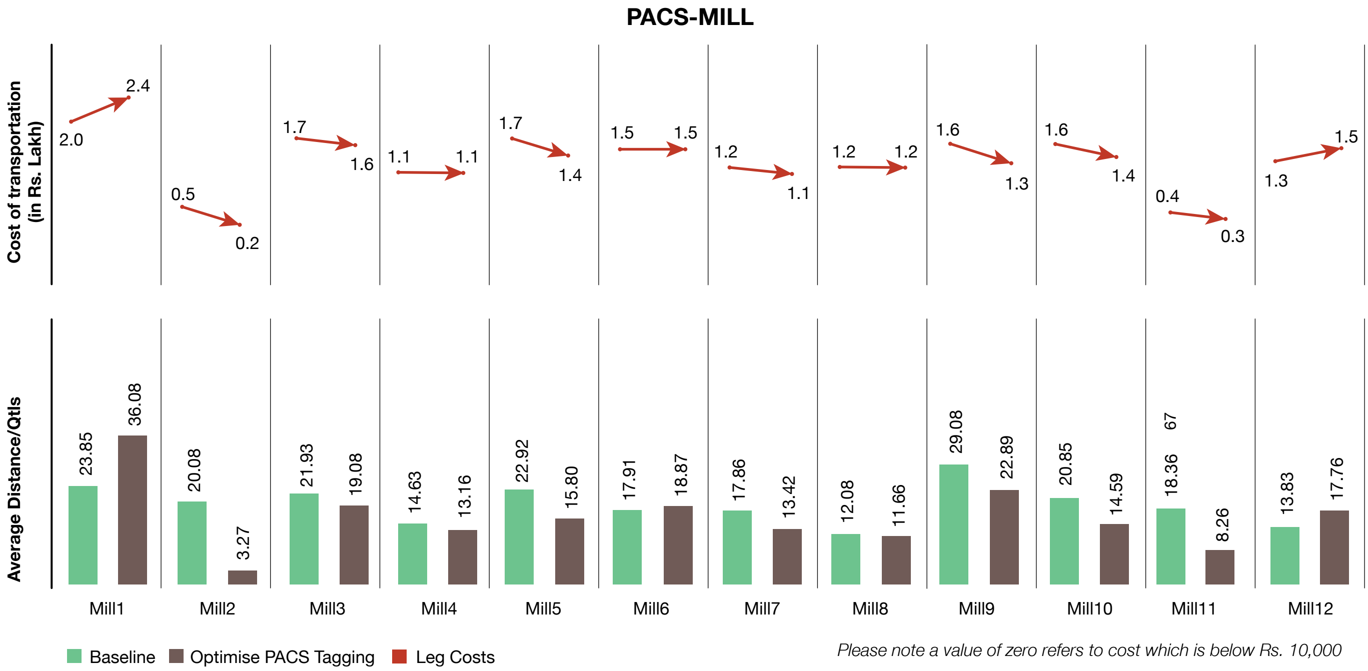


Figure 22: Average Distance/Qtl and cost of transportation from PACS to mills in the optimising PACS tagging scenario

- Figure 22, shows that the average distance/Qtl. of the tagged PACS will increase for only 2 out of the 12 mills but for the rest of the 10 mills the average distance/Qtl. will decrease. The average distance/Qtl. for the Mill2 (BDN Food Products) has shown the most decline from 20.05 Km/Qtl to 3.27 Km/Qtl, because in the baseline this mill was tagged to a lot of PACS even though the allocation of this mill is very low. Therefore, in the optimising PACS tagging scenario, the optimiser chose to only tag it to the 3 PACS that are located nearest to this mill, while reducing the overall cost of transportation.
- Total cost of transportation has reduced by Rs. 87,421 per month which amounts to a saving of about 6% in this leg and about 2% overall.

5.4.2. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE OPTIMISING PACS TAGGING SCENARIO

The geo representation of the baseline and the optimising PACS scenario shows reduction in the network complexity between PACS to Mill in this scenario. (Figure 23)

PACS-MILL
Baseline

PACS-MILL
Optimise PACS Tagging

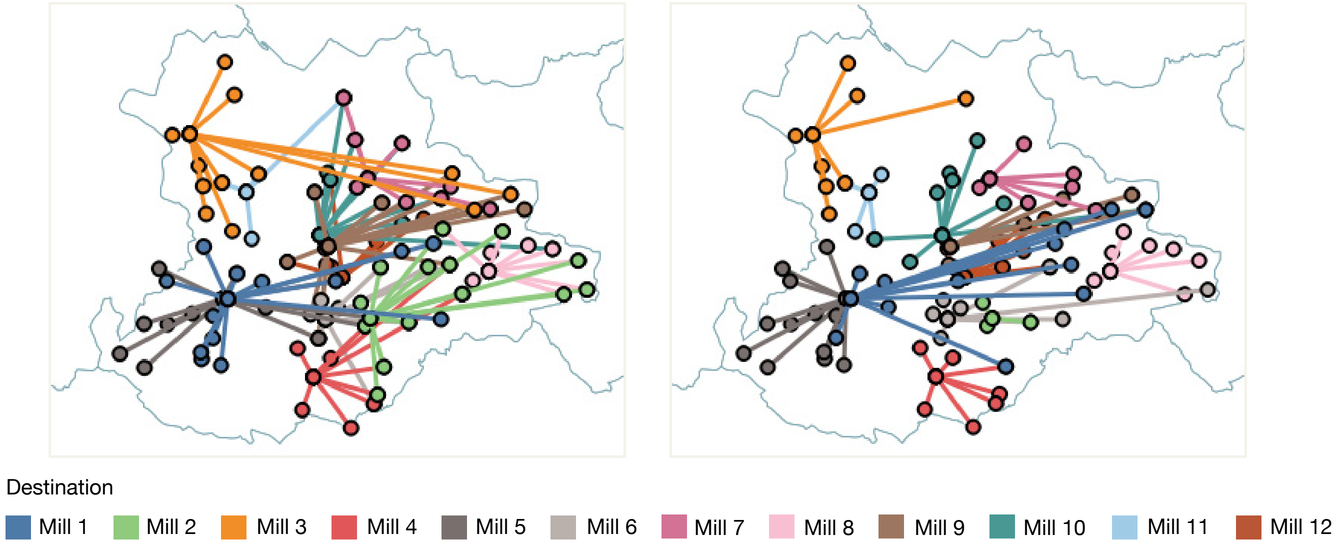


Figure 23: Geo-Representation of tagging in the optimise PACS tagging scenario

5.5. CHANGES REQUIRED TO IMPLEMENT THIS SCENARIO

TECHNICAL CHANGE

- Changes to the P-PAS databases on tagging of nodes: i.e. tagging of PACS to mills in the P-PAS system

OPERATIONAL CHANGE

- Changes in the tagging in Leg 1 i.e. PACS to Mill.
- Preparation of new allocation orders based on the changes in tagging in leg 1 from PACS to Mill. While the changes do not impact the total quantity delivered to each mill, there are changes in the quantities received by mills from each PACS.
- Changes in the planning/execution, delivery schedules and pick up of paddy from PACS to mills.

SCENARIO 3
OPTIMISE LEG 1 AND 2

CHAPTER 6

SCENARIO 3.

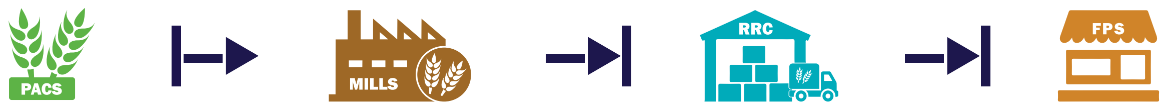
OPTIMISE LEG 1 AND 2

6.1. ABOUT THE SCENARIO

In this scenario, the model optimises leg 1 and 2 i.e. PACS to Mill and Mill to RRC, while keeping leg 3 i.e RRC to FPS as same. For Leg 1, both the tagging and allocation from PACS to Mill are optimised, while for Leg 2 only tagging from Mill to RRC is optimised, total volume allocated to each RRC has been kept the same. Additionally, while optimising, the volume that is allocated to each mill has been changes, while ensuring that it does not exceed the maximum capacity of that mill.

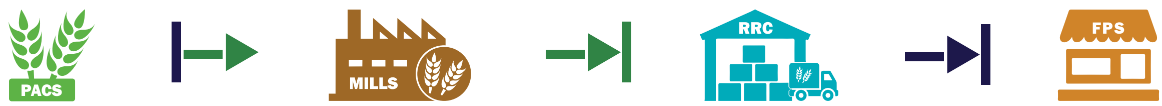
This scenario allows the optimisation model to choose from more possible routes and therefore it is possible to decrease the transportation costs by a lot more than in the optimising PACS scenario. Overall, the total cost saving is 11% or Rs. 5,07,710 per month. The costs for leg 1 have been reduced by 16% from the baseline and the cost for leg 2 have been reduced by 29% from the baseline.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: OPTIMISE LEG 1 AND 2



TTC: Rs. 40,63,924 (-11%) | ADT: 70.7 Km./Qtl. | ATC: 1.38 Rs. per Km./Qtl.

Can be changed *Remains the same* *Can be closed*

Table 16: Summary statistics for scenario Optimising Leg 1&2

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

6.2. KEY CONSTRAINTS

1. All paddy that is procured is transported to one of the mills in the district.
2. All paddy that is procured from the PACS is processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
5. FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
6. All demand for rice and wheat at every FPS must be satisfied.
7. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
8. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
9. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

6.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Optimise Leg 1 and 2	13,22,450 (-16%)	1.33 (+22%)	13.50 (-31%)
MILLS → RRC: Rice (45,000 Qtls)			
Baseline	9,09,631	0.95	19.24
Optimise Leg 1 and 2	6,49,258 (-29%)	1.09 (+15%)	11.87 (-38%)
RRC → FPS: Rice (45,000 Qtls)			
Baseline	16,44,524	1.63	22.40
Optimise Leg 1 and 2	16,44,524	1.63	22.40
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Optimise Leg 1 and 2	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Optimise Leg 1 and 2	2,89,750	1.63	22.22

Table 17: Key output KPI's for optimising leg 1&2 scenario

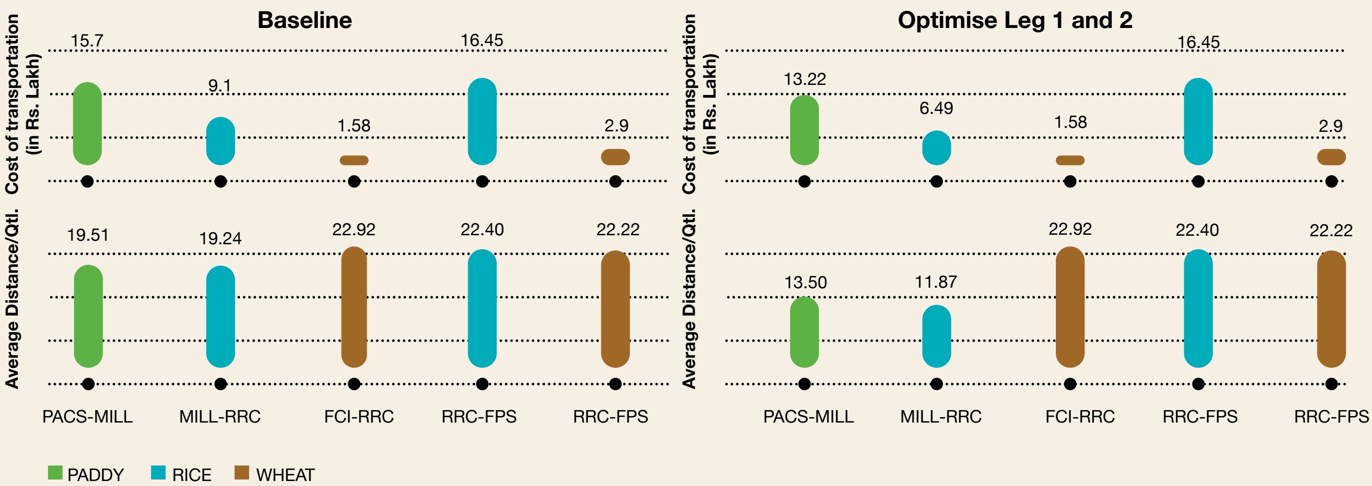


Figure 24: Changes in total cost and distance in all legs for the scenario optimise leg 1 and 2

6.4. CHANGES FROM THE BASELINE

The changes are restricted to Leg 1 and 2 of the supply chain. Overall the costs have reduced by 11% or Rs 5,07,710 per month. For Leg 1 average distance per Qtl. has reduced from 19.51 Km./Qtl to 13.50 Km./Qtl. and for Leg 2 from 19.24 Km./Qtl. to 11.87 Km./Qtl. Table 17 shows that the average transportation costs have increased in Leg 1 and 2. This is largely because the average transportation costs are dependent on total transportation costs, volume and distance (i.e. average transportation costs=total cost of transportation/(volume*distance) and while distance has reduced by 56% and 82% respectively for leg 1 and 2 due to optimisation the cost of transportation in these legs has only reduced by 16% and 29%.

OBSERVATIONS FOR LEG 1: PACS TO MILL

6.4.2.1. TAGGING AND VOLUME

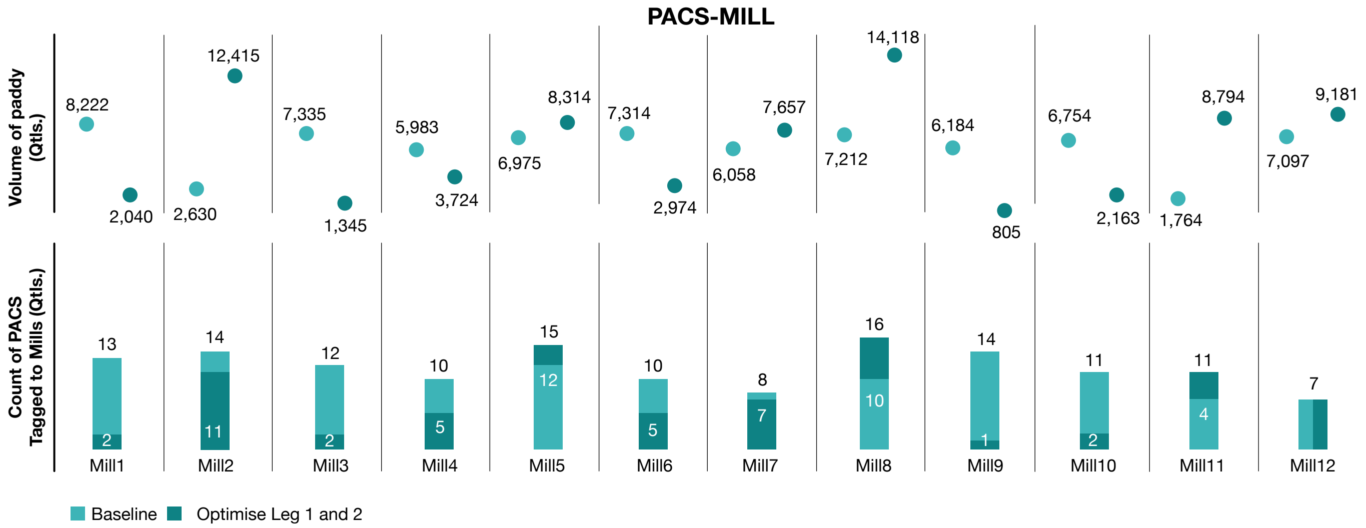


Figure 25: Tagging and volume of paddy from PACS to mills in the optimising leg 1&2 scenario

- Tagging and volume from PACS to Mill have been reallocated to optimise the overall costs. For example: Mill 1(Annapurna rice mill) was tagged to 13 PACS in the baseline, but after the optimisation, allocation to the mill has been reduced from 8,222 Qtls. to 2040 Qtls and the number of PACS tagged to it have reduced to 2. On the other hand, tagging to Mill 2 (BDN Food Products) has reduced, but allocation has been increased six times than the baseline.
- Number of nodes traversed in this leg have decreased from 125 to 84. (Figure 25).

6.4.2.2. DISTANCE AND COSTS

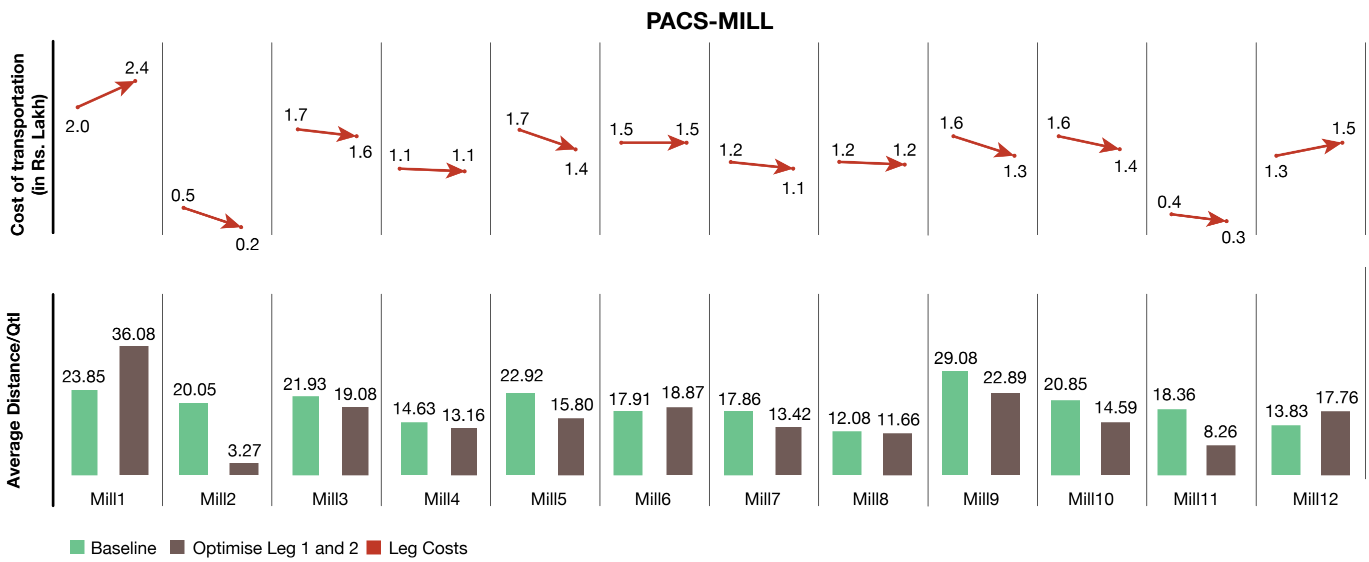


Figure 26: Distance and cost of transportation from PACS to mills in the optimising leg 1 and 2 scenario

- As a result of the changes in the tagging and allocation between PACS to mills, there are changes in the distance and cost of transportation between PACS and Mills. (Figure 26).
- Mill 2 i.e. BDN Food Products has shown the most increase in costs of transportation from Rs. 50000 to ~2 lakhs, even though the distance travelled per Qtl. has reduced significantly. This is because the volume handled by Mill 2 has increased 5 times, and the costs are linked to both distance and quantity of food grains.

6.4.1. OBSERVATIONS FOR LEG 2: MILL TO RRC

6.4.1.1. TAGGING AND VOLUME

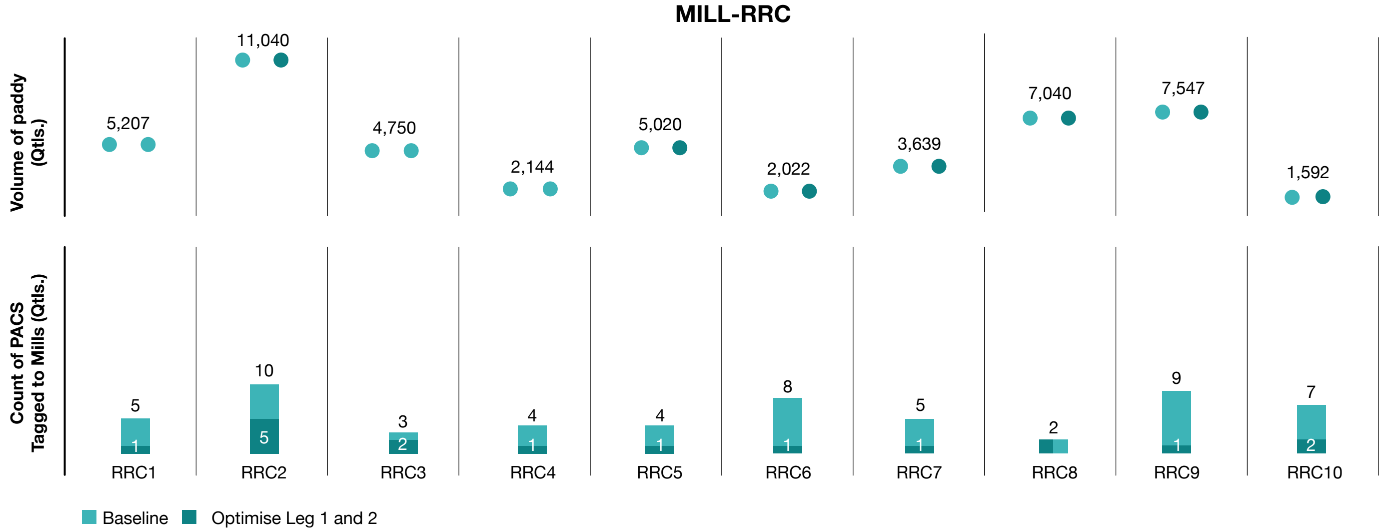
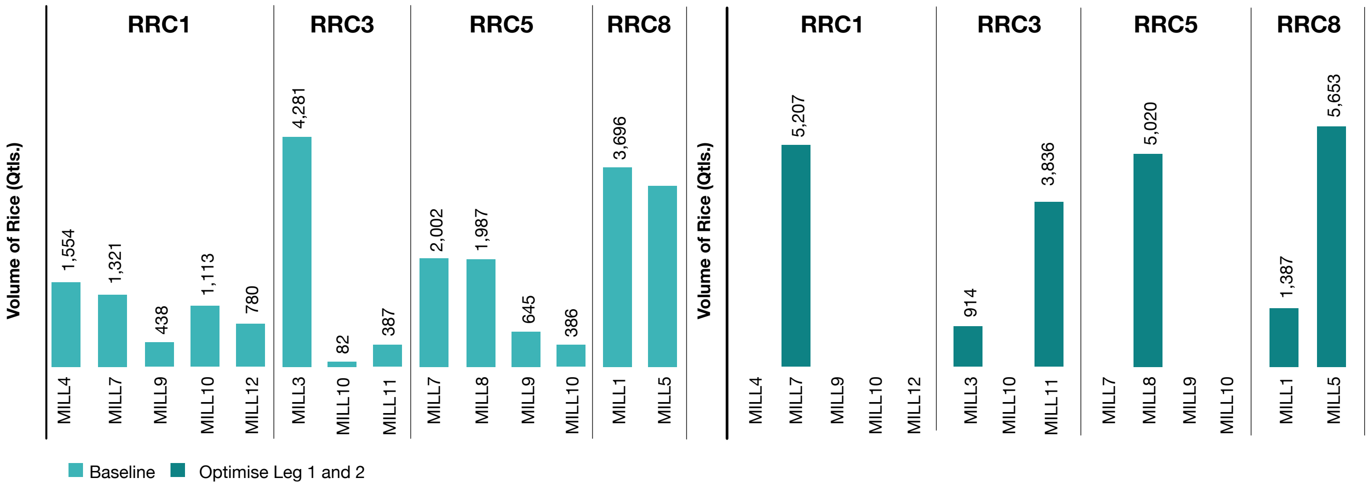


Figure 27: Tagging of mills to RRCs in the optimising leg 1 and 2 scenario

- The total number of nodes have reduced from 57 in the baseline to 17 in this scenario. For example, four mills were tagged to Bhubhan RRC in baseline, while in the optimising leg 1 and 2 scenario only 1 mill is tagged. (Figure 27).
- A few examples of changes in the volume of rice from each mill to each RRC in this scenario as compared to the baseline is shown in Figure 28.



- The optimisation model ensures that the total allocation to each RRC remains same, such that there is no impact on Leg 3 i.e RRC to FPS. E.g. RRC 1 in the optimising leg 1 and 2 scenario is only tagged to one Mill instead of 5 in the baseline, but the total volume allocated to the RRC is same as in the baseline.

6.4.1.2. DISTANCE AND COSTS

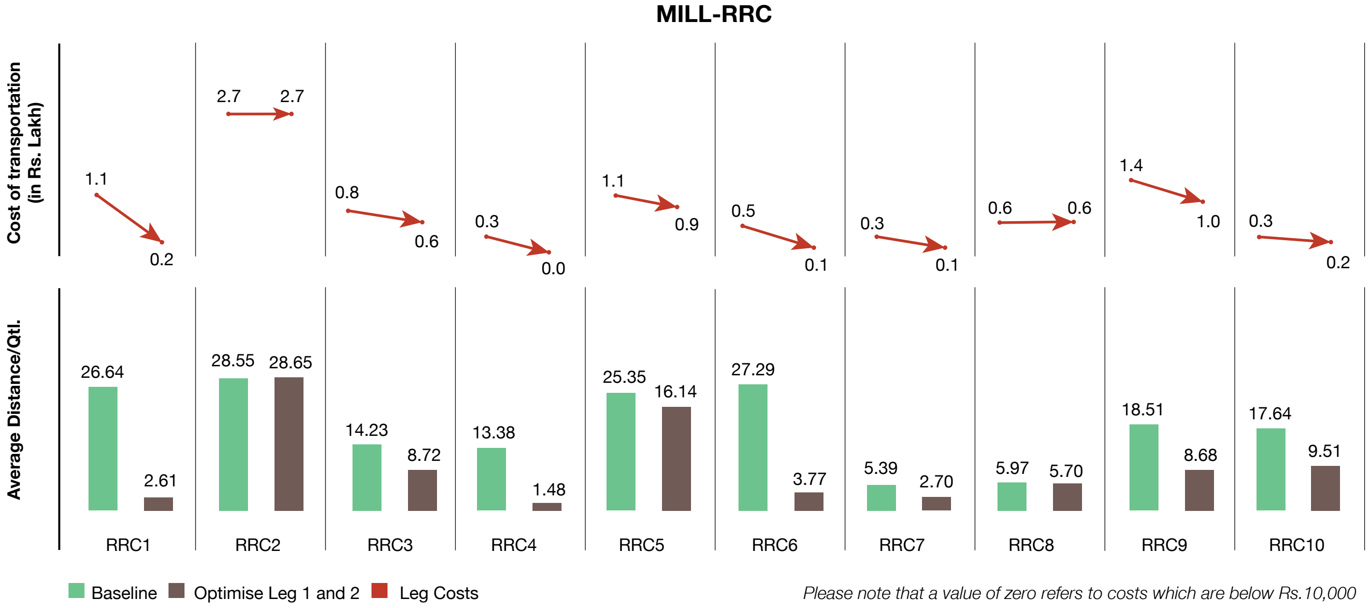


Figure 29: Distance and costs of transportation from mills to RRCs in the optimising leg 1 and 2 scenario

Figure 29, describes the changes in the average distance/Qtl and the total cost for transportation in Leg 2 for the optimising leg 1 and 2 scenario. Cost of transportation has reduced for all nodes between Mill to RRC due to changes in tagging and distance travelled between nodes.

6.4.2. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN OPTIMISING LEG 1 AND 2

The maps display the tagging of PACS to Mill and Mill to RRC. It can be observed that the transportation of paddy from east to west has been rationalised, thereby reducing the overall costs without change in the supply volume (demand) of the FPS and RRCs. (Figure 30, 31).

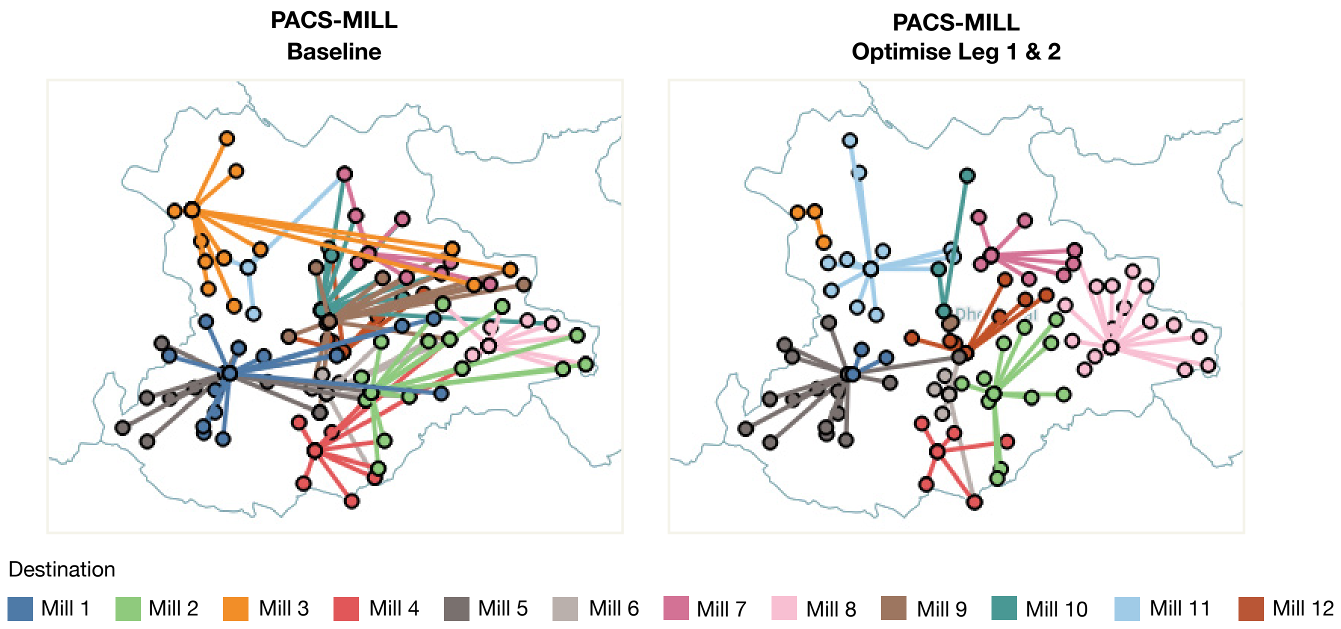


Figure 30: Geo-representation of tagging between PACS and mills in the optimising leg 1 and 2 scenario

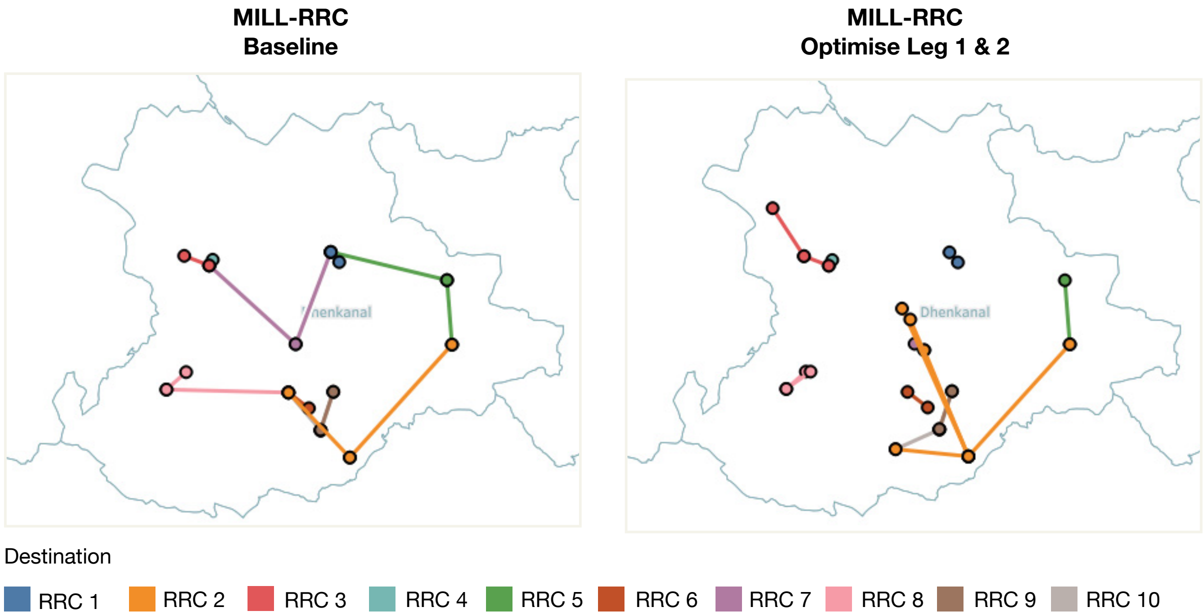


Figure 31: Geo-representation of tagging between Mill and RRC in the optimising leg 1 and 2 scenario

6.5. CHANGES REQUIRED TO IMPLEMENT THE SCENARIO

TECHNICAL CHANGE

- Changes to the SCMS and P-PAS databases on **tagging of nodes:** i.e. tagging of mills to RRCs in SCMS and tagging of PACS to mills in the P-PAS system.
- Changes to the P-PAS and miller database on the **allocation of grains to mills** i.e. allocation of mills in P-PAS.

OPERATIONAL CHANGE

- Changes to existing contracts/prepare new contract for the next procurement cycle for mills to accommodate transportation and other changes as a result of revised tagging and allocation.
- Changes in the tagging and volume from PACS to Mills and changes in tagging for Mills to RRC.
- Preparation of new allocation orders based on the changes in tagging of PACS to Mills and Mills to RRC. While the changes do not impact the total quantity delivered to each RRC, there are changes in the quantities received by RRC from each Mill.
- Changes in the planning/execution, delivery schedules and pick up of paddy from PACS to Mills and Mills to RRC.

SCENARIO 4
OPTIMISE FPS TAGGING

CHAPTER 7

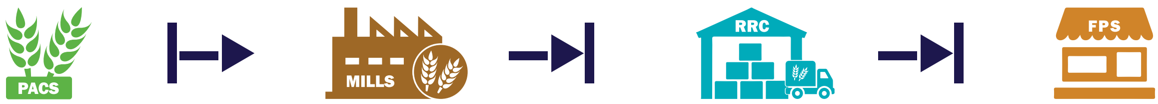
SCENARIO 4.
OPTIMISE FPS TAGGING

7.1. ABOUT THE SCENARIO

In this scenario, changes are made only in the tagging of FPS to RRC, while the configuration (tagging and volume) of leg 1 and 2, i.e PACS to mills and mills to RRC remains the same as in the baseline. Under the current transport contract for the last leg i.e. RRC to FPS, it is not possible to minimise the costs because the costs are only dependent on volume (i.e per Qtl defined per block) and not on travelled distance (Refer table 4 in section 2.3 for the details on costs). Additionally, in this scenario the volume allotted to each FPS is not altered to ensure fulfillment of demand at FPS, therefore costs savings cannot be achieved unless the changes in tagging and resultant decrease in distance is reflected in the transport cost. Thus, to analyse these savings for this scenario, the calculated costs of transportation for leg 3 i.e. RRC to FPS (refer to Table 9) of Rs.1.63 per Qtl. per Km. have been used.

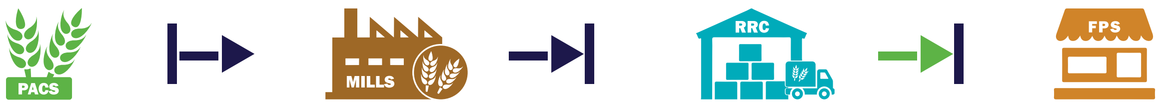
Overall, with the changes in tagging and change in contract modality from exsiting per Qtl. cost to the calculated rate which is per Qtl. per Km. overlooking the administrative boundaries of the block, 9% cost savings from the baseline can be achieved.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: OPTIMISE FPS TAGGING



TTC: Rs. 41,80,933 (-9%) | ADT: 79.5 KM./QTL. | ATC: 1.19 RS. PER KM./QTL.

Can be changed *Remains the same* *Can be closed*

Table 18: Summary statistics for scenario optimising FPS tagging

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

7.2. KEY CONSTRAINTS

1. Every PACS can only supply a mill that it's connected to according to the current PACS tagging.
2. All paddy that is procured is transported to one of the mills in the district.
3. All paddy that is procured from the PACS is processed by the mills.
4. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
5. The volumes of rice that are being transported from mills to RRCs are given by the data.
6. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
7. All demand for rice and wheat at every FPS must be satisfied.
8. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
9. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

7.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Optimise FPS Tagging	15,69,794	1.09	19.51
MILLS → RRC: Rice (45,000 Qtls)			
Baseline	9,09,631	0.95	19.24
Optimise FPS Tagging	9,09,631	0.95	19.24
RRC → FPS: Rice (45,000 Qtls)			
Baseline	16,44,524	1.63	22.40
Optimise FPS Tagging	13,26,471 (-19%)	1.63	18.08 (-19%)
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Optimise FPS Tagging	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Optimise FPS Tagging	2,17,095 (-25%)	1.63	16.65 (-25%)

Table 19: Key output KPI's for optimising leg 1&2 scenario

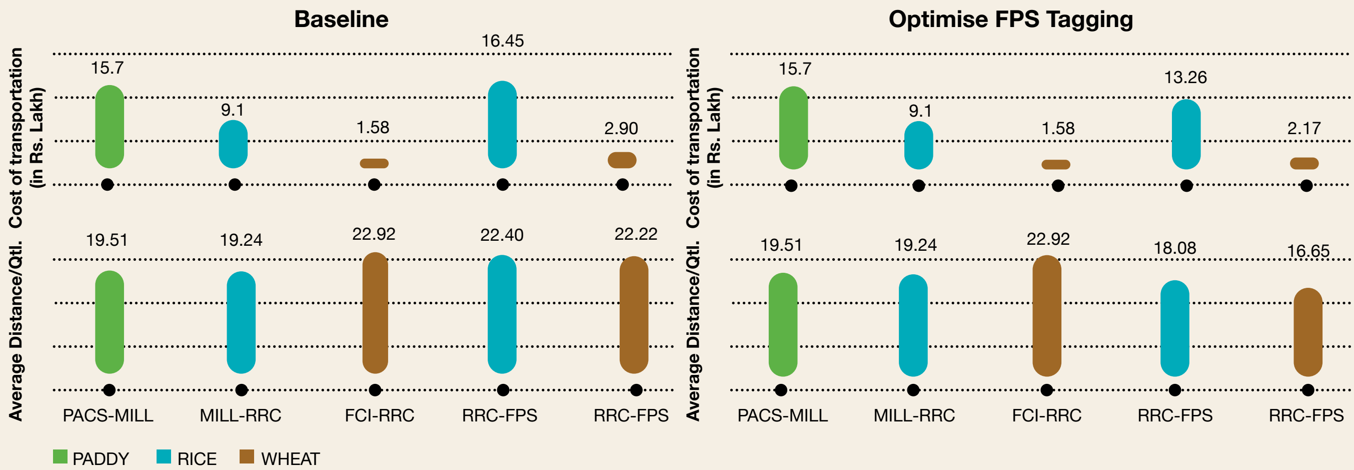


Figure 32: Total distance and cost of transportation for all legs in the optimising FPS tagging scenario

7.4. CHANGES FROM THE BASELINE

Changes are made only to the last leg i.e. RRC to FPS, hence all the observation relate to only this leg. Overall the cost savings are 9% from the baseline or Rs. 3,90,707 monthly. Below are the key changes:

7.4.1. OBSERVATIONS FOR LEG 3: RRC TO FPS

7.4.1.1. TAGGING AND VOLUME

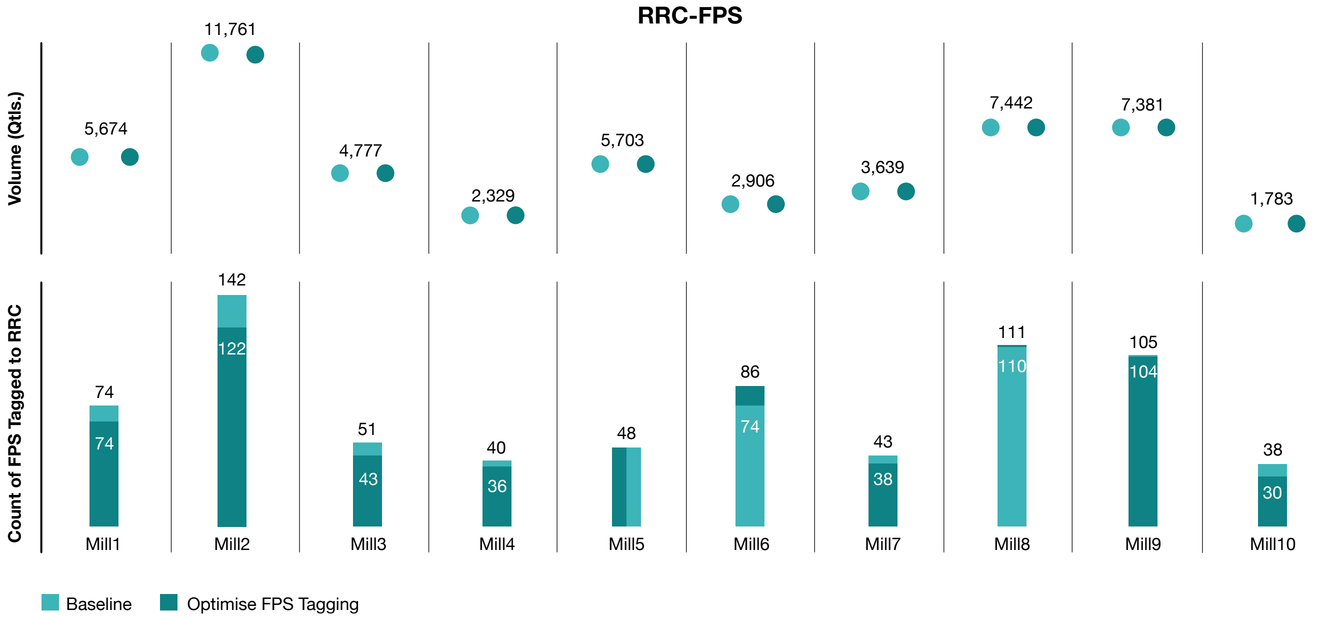


Figure 33: Tagging of FPS to RRCs (Rice) in the optimising FPS tagging scenario

There are changes to tagging of 356 out of 565 FPSs. Figure 33 describes the changes in tagging between baseline and the optimisation scenario for both rice and wheat.

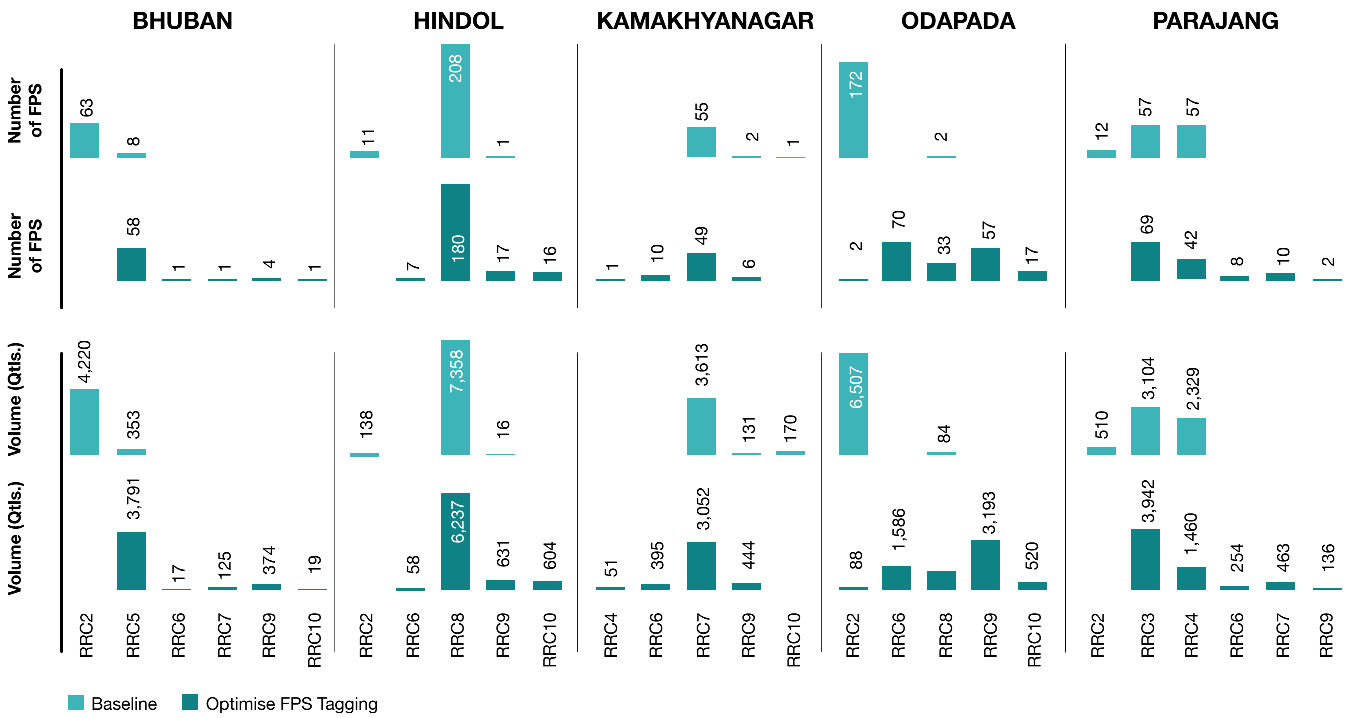


Figure 34: Volume of rice and wheat from RRC to FPS in each block in the optimise FPS tagging scenario

For some blocks the tagging has changed drastically e.g. Odapada and Bhubhan, where during the analyis it can be observed that most of the Fair Price Shops are tagged to a different RRC in the baseline. It can also be observed that for some blocks the tagging remains largely the same e.g. Parjang, Hindol. (Figure 34)

7.4.1.2. DISTANCE AND COSTS

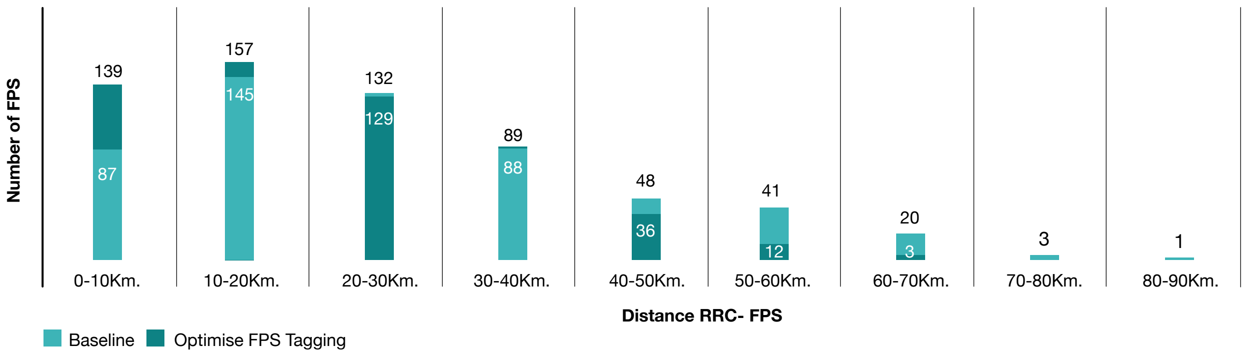


Figure 35: Distance travelled by FPS in the leg: RRC to FPS in the optimising FPS tagging scenario

- Maximum FPS are tagged within a distance of 0-50 km from the tagged RRC, with an upward shift from 89 in the baseline to 139 within the 0-10 km distance in the revised FPS tagging. Number of FPS in the 50-90 Km ranges has been reduced from the tagged RRC 65 to 23. Overall, the average distance from RRC to FPS hs been reduced by 21%.

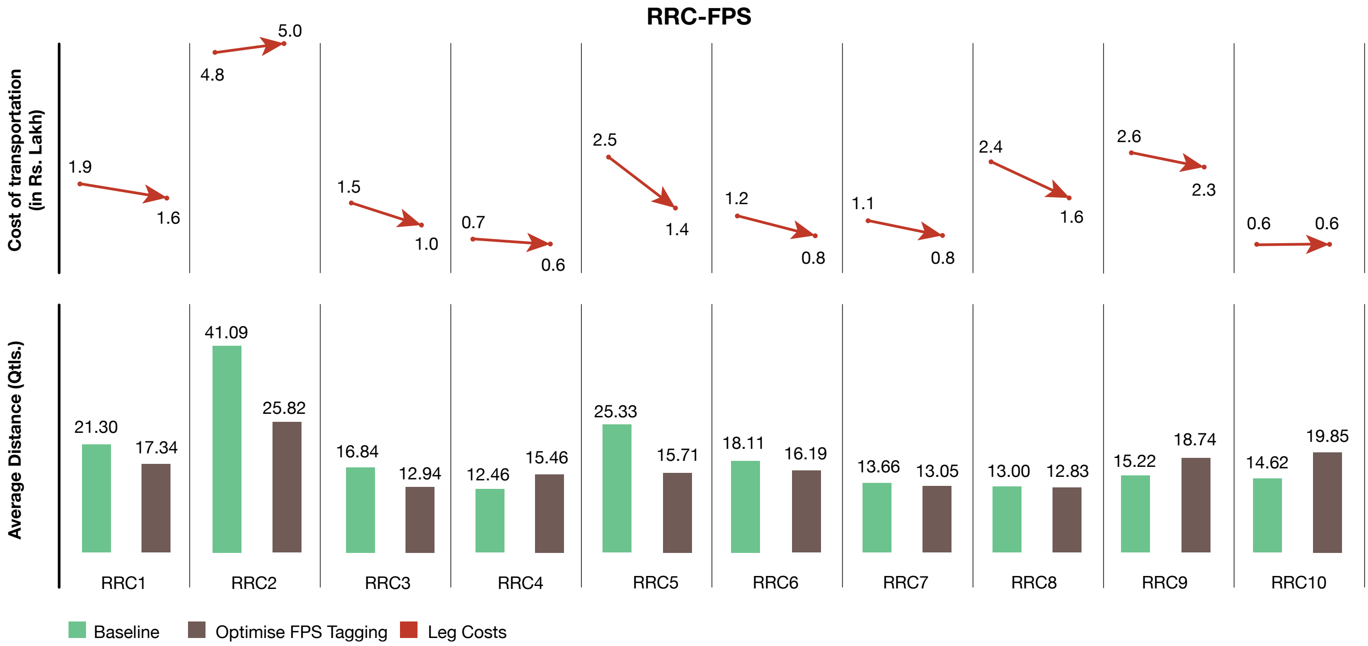


Figure 36: Cost of transportation from RRC to FPS in the scenario optimising FPS tagging

- Figure 36, describes the cost of transport from each RRC to FPS for both rice and wheat. It can be observed that costs have come down for each RRC except for RRC 2 (Baladiabandha).
- As per the current/prevalent transportation contract the cost of transportation is dependant only on the volume (Rs./Qtl.), this combined with the restriction of block boundries results in higher costs to GoO. Thus to calculate the cost savings due to change in tagging and distance between nodes, the derived rate of Rs. 1.63 per Km. per Qtl. (refer table 9) has been used. At the derived cost, cost decrease of ~20% in the last leg which results in an overall saving of 9% of total costs can be achieved.

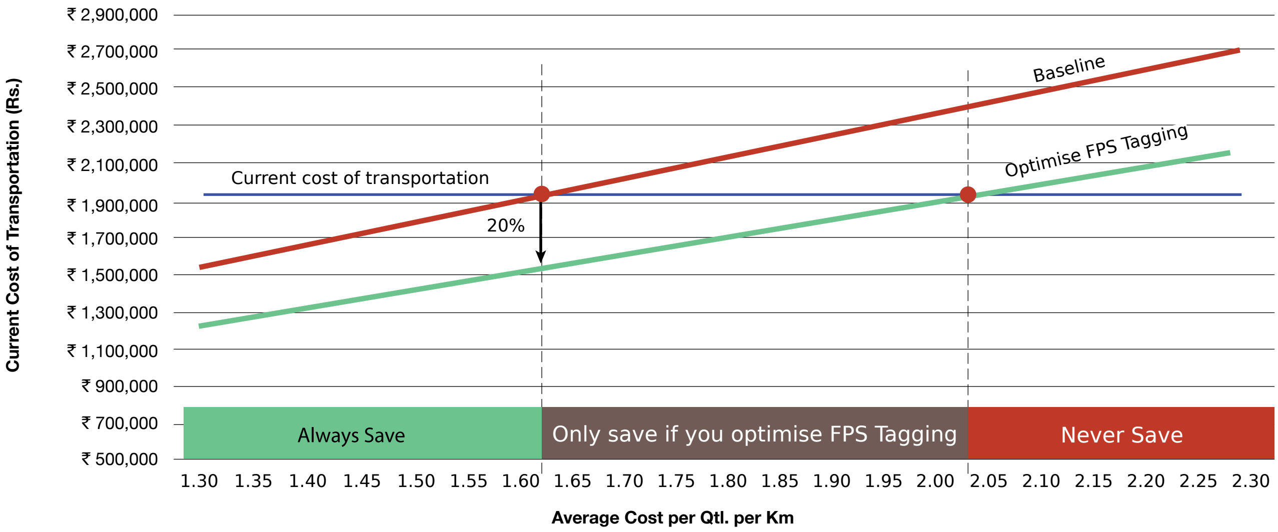


Figure 37: Analysis of savings over a range of transportation rates for the last leg

Figure 37, shows the savings at the derived rate of Rs. 1.63 per Km. per Qtl. as well as the range over which savings are feasible in this optimisation scenario. The graph shows that if the transportation rate is below Rs. 1.63 per Km. per Qtl. then there are always savings. However, if the costs are between Rs. 1.63 and Rs. 2.04 per Km. per Qtl. then savings are feasible only if tagging of RRC to FPS is optimised. At a rate which is above Rs. 2.04 per Km. per Qtl. costs will be higher than exsiting prevelant costs, hence GoO should aim to keep the rate less than Rs. 2.04 per Km. per Qtl.

7.4.2. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN OPTIMISING FPS TAGGING

Figure 38, represents the tagging of RRCs to FPS. FPS tagging is now more clustered, which could be used for contracting transporter. The inefficiencies where grain was travelling from west to east have also been rationalised.

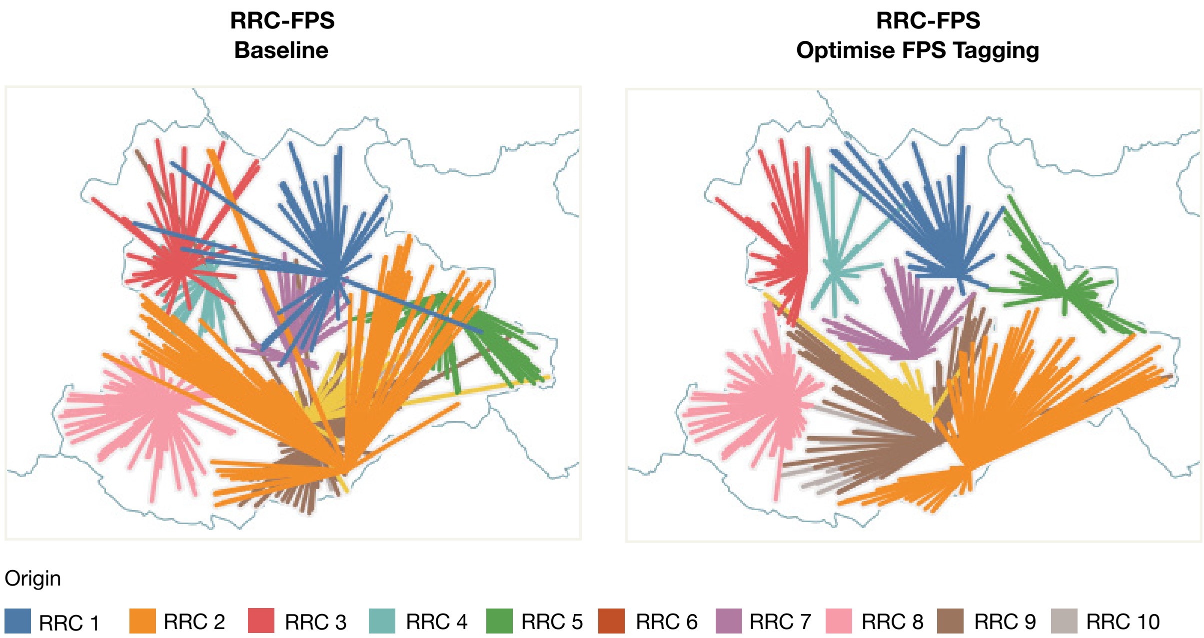


Figure 38: Geo-representation of tagging from RRC to FPS in the optimising FPS tagging scenario

7.5. CHANGES REQUIRED TO IMPLEMENT THIS SCENARIO

POLICY CHANGES

- Classification of supply zones in the food security rules and assigning of responsibilities.
- Revision in the methodology for contracting of transporters including contracting terms, transportation rate etc. to accommodate recommendation to move from per Qtl. rate to per Qtl. per Km. rate for the last leg i.e. RRC to FPS.

TECHNICAL CHANGE

- Changes to the SCMS and FPS automation systems on tagging of nodes: i.e. tagging of RRC to FPS for allocation, movement and receipt of grains.

OPERATIONAL CHANGE

- Contracting of new transport agents (L2 transporters) or changes to existing contracts to accommodate changes in rates of transportation, allocation and tagging.
- Preparation of new allocation orders based on the changes in tagging of RRC.
- Changes in the planning/execution, delivery schedules and pick up of rice and wheat from RRC's to FPS.

SCENARIO 5
CLOSING MILLS

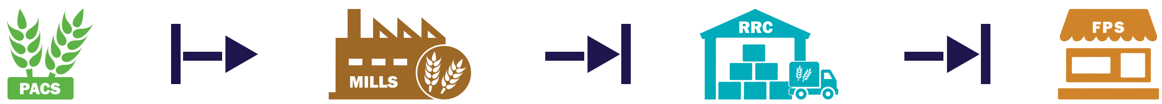
CHAPTER 8

SCENARIO 5.
CLOSING MILLS

8.1. ABOUT THE SCENARIO

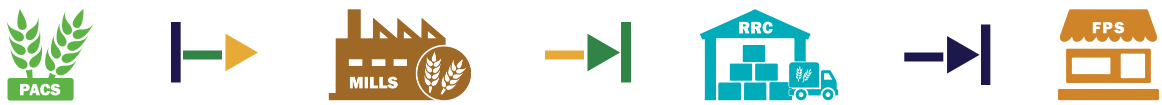
This scenario quantifies the impact of closing a few mills in Dhenkanal district and its impact on the total transportation costs. This scenario is similar to Scenario 3: Optimising leg 1 & 2, with additional conditions which include: each mill is either be closed or used to its full capacity to maximise the usage of available resources, and that the volume at each RRC is kept same as in the baseline. The average transportation costs in this scenario will be higher because closing down some mills will increase the distance that each Qtl. of paddy and rice has to travel to and from the mills. Overall, the cost savings in this scenario are 6% from the baseline or Rs. 2,79,565, with savings of 10% and 14% in Leg 1 and 2 respectively.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: CLOSING MILLS



TTC: RS. 42,92,075 (-6%) | ADT: 76.2 KM./QTL. | ATC: 1.31 RS. PER KM./QTL.

Can be changed *Remains the same* *Can be closed*

Table 20: Summary statistics for the scenario closing mills

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

8.2. KEY CONSTRAINT

1. All paddy that is procured must be transported to one of the mills in the district.
2. All paddy that is procured from the PACS must be processed by the mills.
3. All mills have an efficiency of 68%. For every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
5. All demand for rice and wheat at every FPS must be satisfied.
6. All wheat demand flows into the district at the FCI (Dhenkanal).
7. Each FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
8. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
9. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.
10. Each mill should either be closed or it should be used to 90% of its full capacity in order to maximise the usage of available resources.

8.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Closing Mills	14,19,838 (-10%)	1.28 (+17%)	15.13 (-22%)
MILLS → RRC: Rice (45,000 Qtls)			
Baseline	9,09,631	0.95	19.24
Closing Mills	7,80,022 (-14%)	0.99 (+4%)	15.78 (-18%)
RRC → FPS: Rice (45,000 Qtls)			
Baseline	16,44,524	1.63	22.40
Closing Mills	16,44,524	1.63	22.40
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Closing Mills	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Closing Mills	2,89,750	1.63	22.22

Table 21: Key output KPI's for scenario closing mills (costs in Rs.)

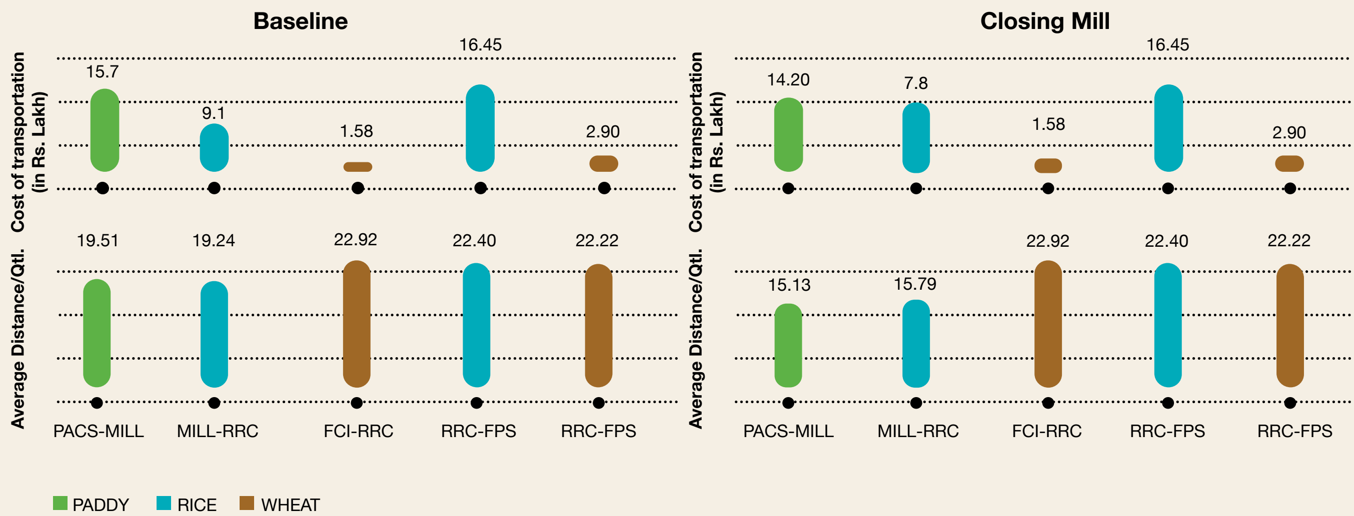


Figure 39: Total distance and costs of transportation by each leg for the closing mills scenario

8.4. CHANGES FROM THE BASELINE

The optimiser chooses to close 6 out of 12 mills and only keeps the ones that are relatively centrally located within the district. While, closure of mills impacts all legs of the supply chain in this scenario, a constraint has been placed that the volume at each RRC be kept same. Thus, the observations in the sections below are for Leg1 and 2 only. Overall the average cost of transportation for both leg 1 and 2 has increased, but the total costs have reduced by Rs. 1.5 lakhs and Rs. 1.3 lakh monthly for Leg 1 and 2 respectively.

8.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

8.4.1.1. TAGGING AND VOLUME

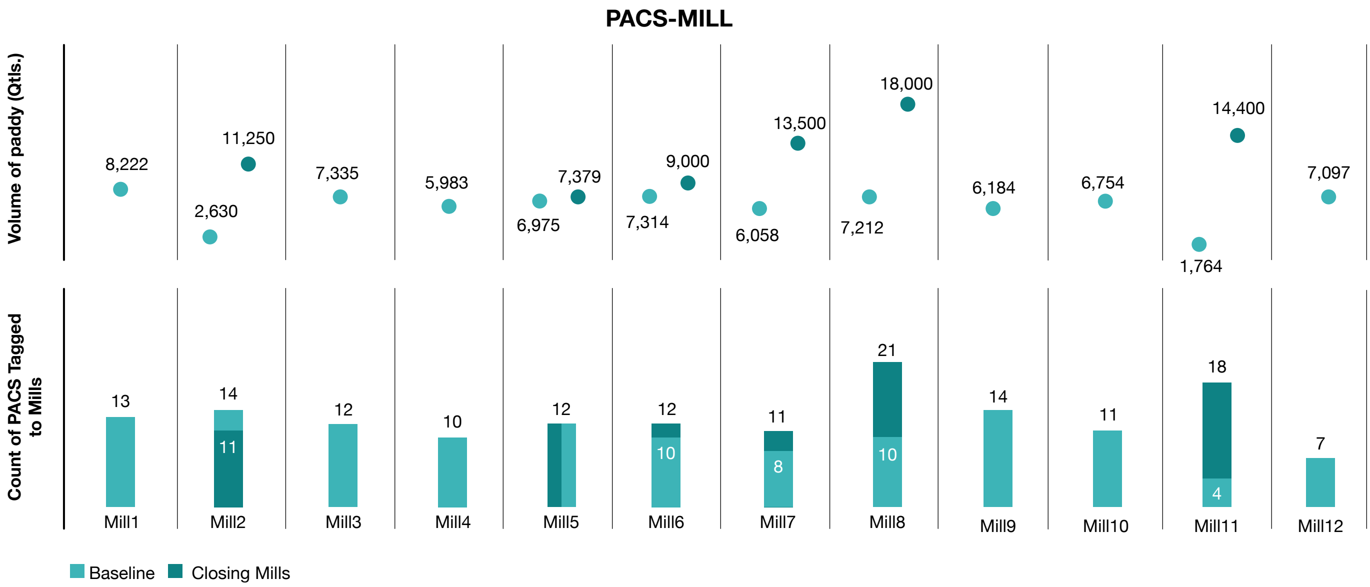


Figure 40: Changes in tagging and volume from PACS to mills in the closing mills scenario

- Figure 40, shows the change in allocation to mill across the baseline and closing mills scenarios. Overall Mill 8 i.e. Maa Tareni Rice mill has been allocated the highest volume of paddy.
- The number of nodes traversed from PACS to mills have reduced from 125 to 85 in this scenario.
- It can be observed that if in the optimise leg 1 & 2 scenario allocation to a mill was reduced in comparison to the baseline, in the closing mills scenario the mill has been closed. (Refer figure 26, 40)
- In cases where in the optimise leg 1 & 2 scenario, the throughput of the mill has been increased in comparison to the baseline, in this scenario mill is assigned to it full capacity. These results are on expected lines, since in both scenarios utilisation is determined by the proximity to the PACS and RRCs.

8.4.1.2. DISTANCE AND COSTS

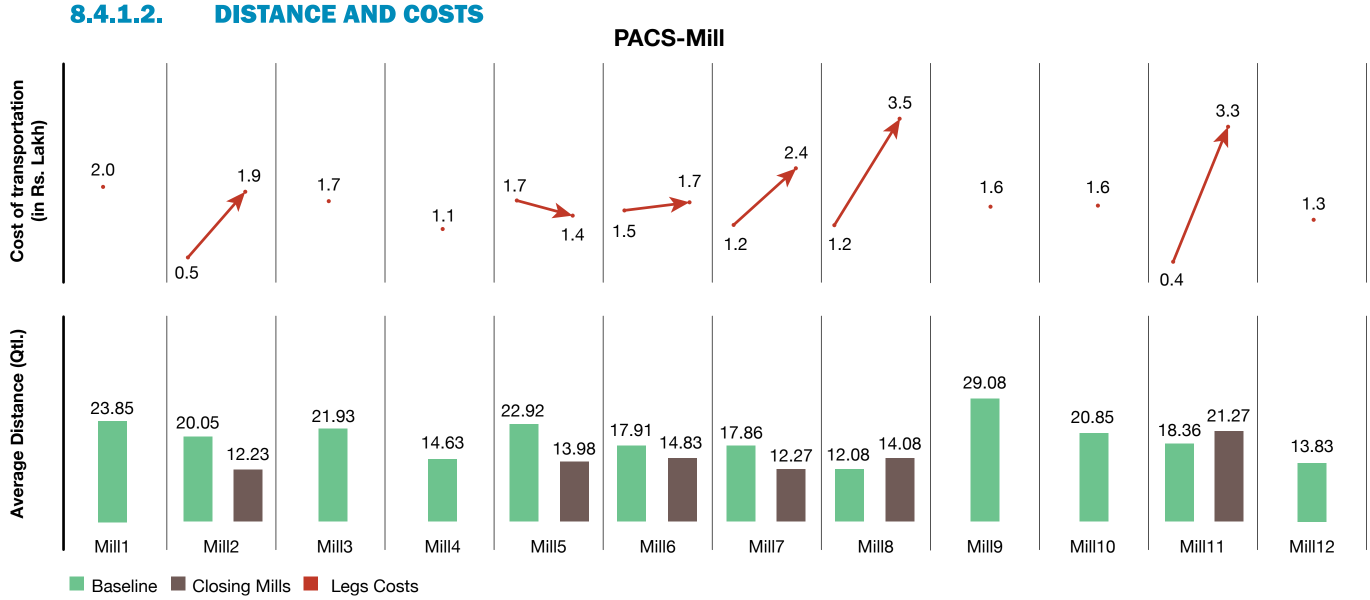


Figure 41: Distance and cost of transportation from PACS to Mills in the closing mills scenario

- Figure 41, describes the changes in distance and cost of transportation with closing of 6 out of 12 mills. Overall, the distance has reduced by 1,310 Km. and costs have reduced by Rs. 1.5 lakhs per month.
- It can be observed that cost has increased for most mills, but even then, the total cost in this leg has reduced by 10%. Highest cost increase has been for Mills 8 and Mill 11, since both tagging and volume allocated to these mills have increased.

8.4.2. OBSERVATIONS FOR LEG 2: MILL TO RRC

8.4.2.1. TAGGING AND VOLUME

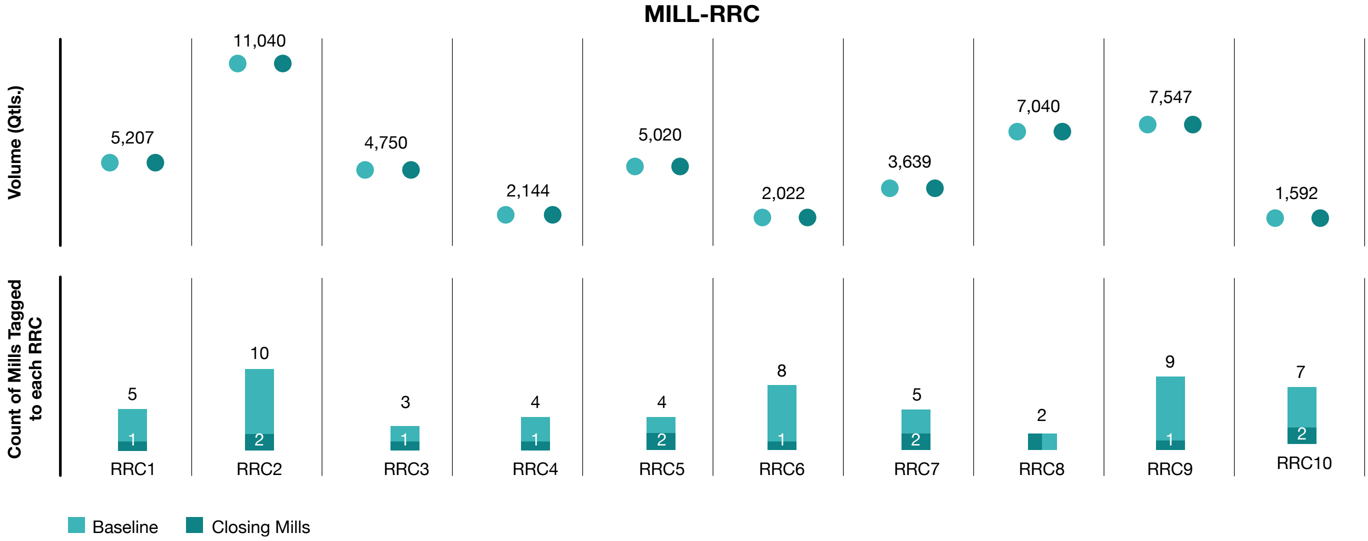


Figure 42: Tagging of mills to RRC in the closing mills scenario

- Figure 42, describes the revised tagging between mills and RRC after closing 6 mills. The number of nodes traversed have decreased from 57 to 15.
- Out of 10 RRC's, 5 are tagged to only 1 Mill, while in the baseline they were tagged to as high as 9,10 mills. The changes to tagging have been done while ensuring that the total volume at each RRC remains same.

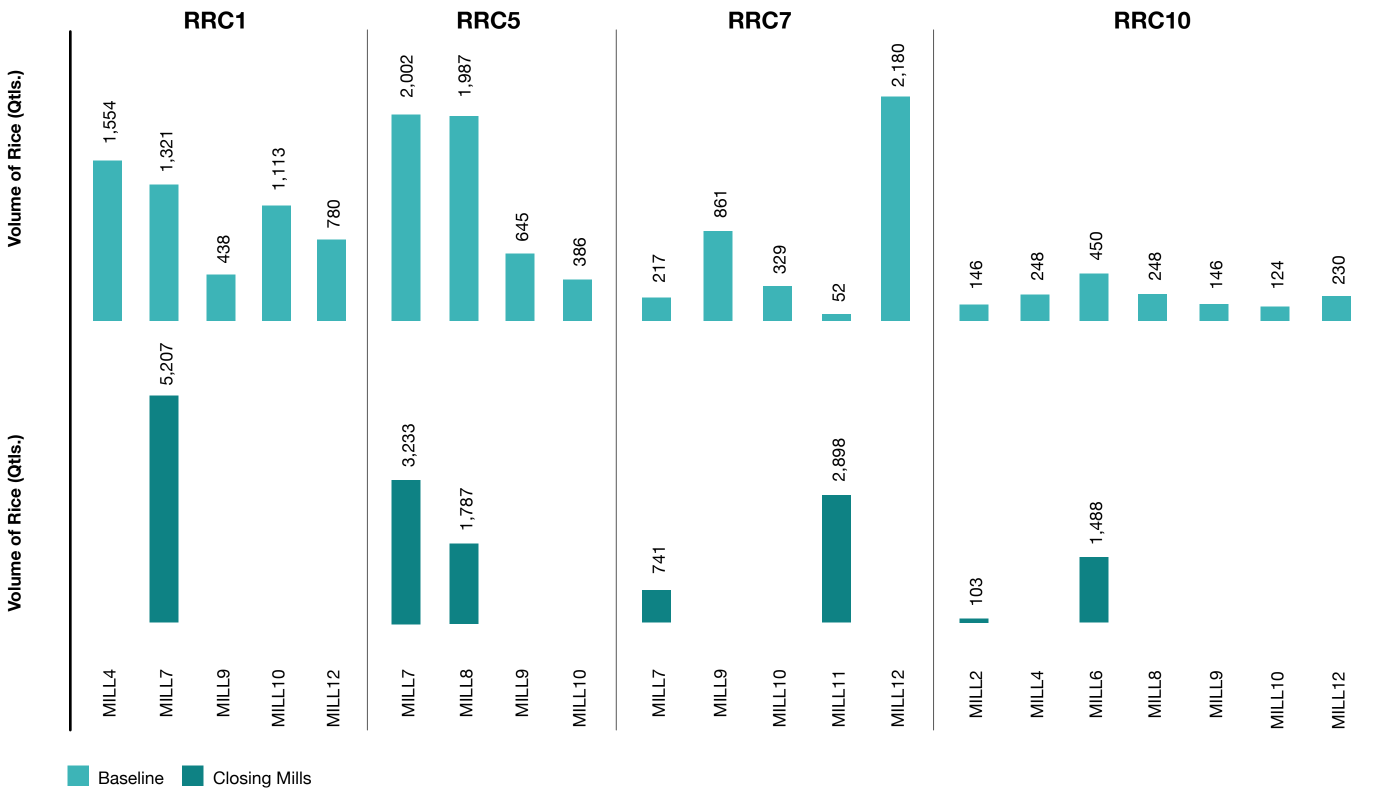


Figure 43: Changes in volume of rice from mills to RRC in the closing mills scenario

- With the closure of mills (1, 3, 4, 9, 10, 12) the volume of rice from other mills have increased considerably to match their full capacity and the demand of the tagged RRC. Figure 43, shows a few examples of how volume from each mill to each RRC has changed.

8.4.2.2. DISTANCE AND COSTS

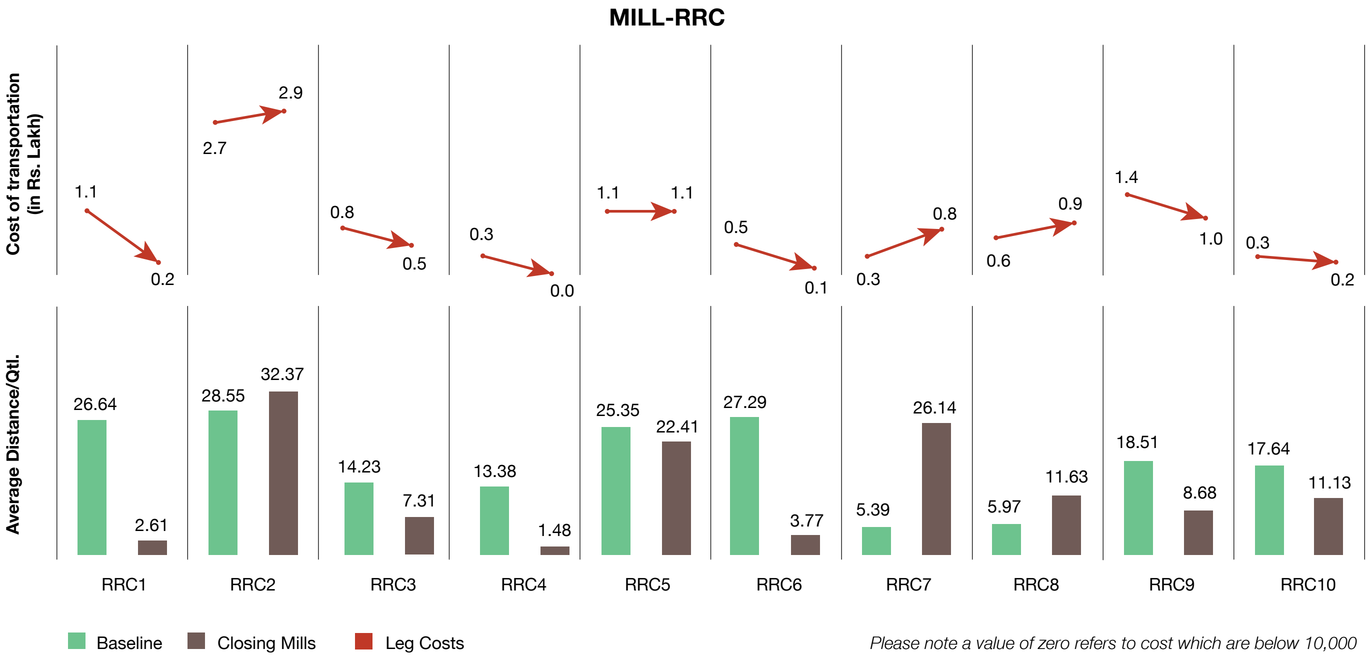


Figure 44: Changes in distance and cost of transportation from mills to RRC in the closing mills scenario

- Figure 44, shows that with the change in distance and volumes delivered from each mill, the cumulative cost of transportation has reduced by 14% or Rs. 1.3 lakhs per month.
- For RRC5 (Bhubhan), even though the average distance per Qtl. has reduced, there is no/minimal change in the cost of transportation. This is because of the 4 mills the RRC was tagged to in the baseline, 2 Mills i.e. Mill 7 (Maa Kamakhi Food Processor) and Mill 9 (Natural Agritech Pvt. Ltd.) which were supplying the highest volume of rice are still tagged to RRC 5 in the closing mills scenario.

8.4.3. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN CLOSING MILLS SCENARIO

Geo spatial representation of PACS to Mill and Mill to RRC in the closing mills scenario is as shown in Figure 45 and 46. With closing mills, distances between certain PACS and mills will increase but overall the scenario shows the maps to be comparatively cleaner and optimised.

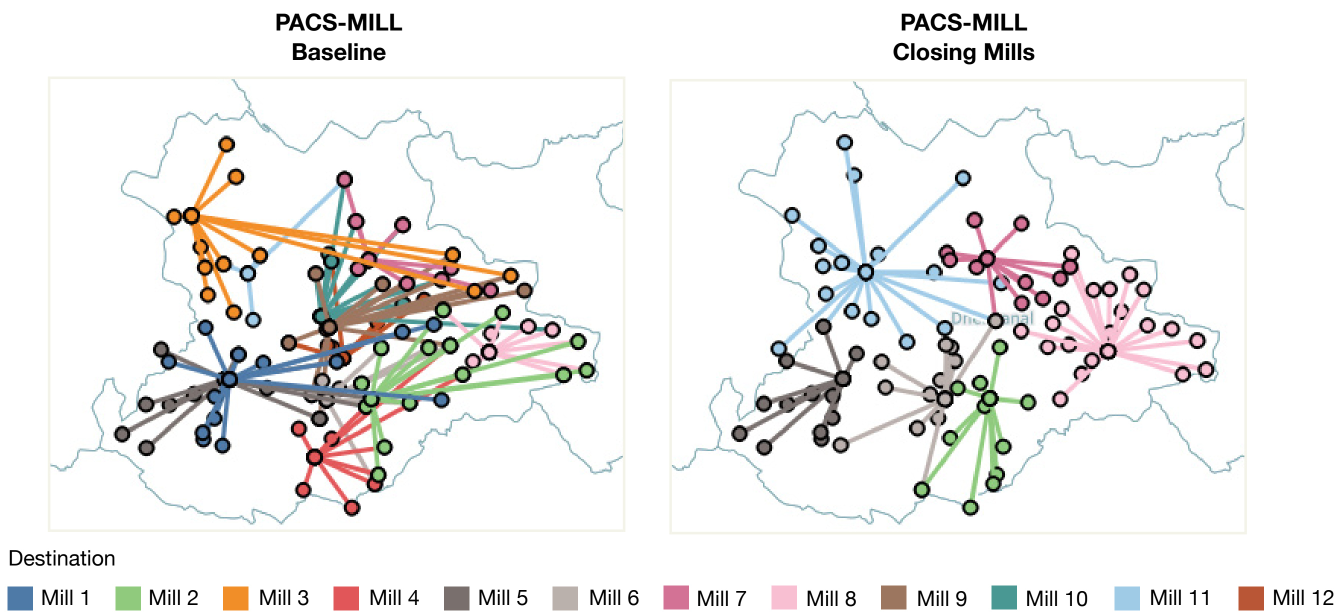


Figure 45: Geo-representation of tagging of PACS to Mill in the closing mills scenario

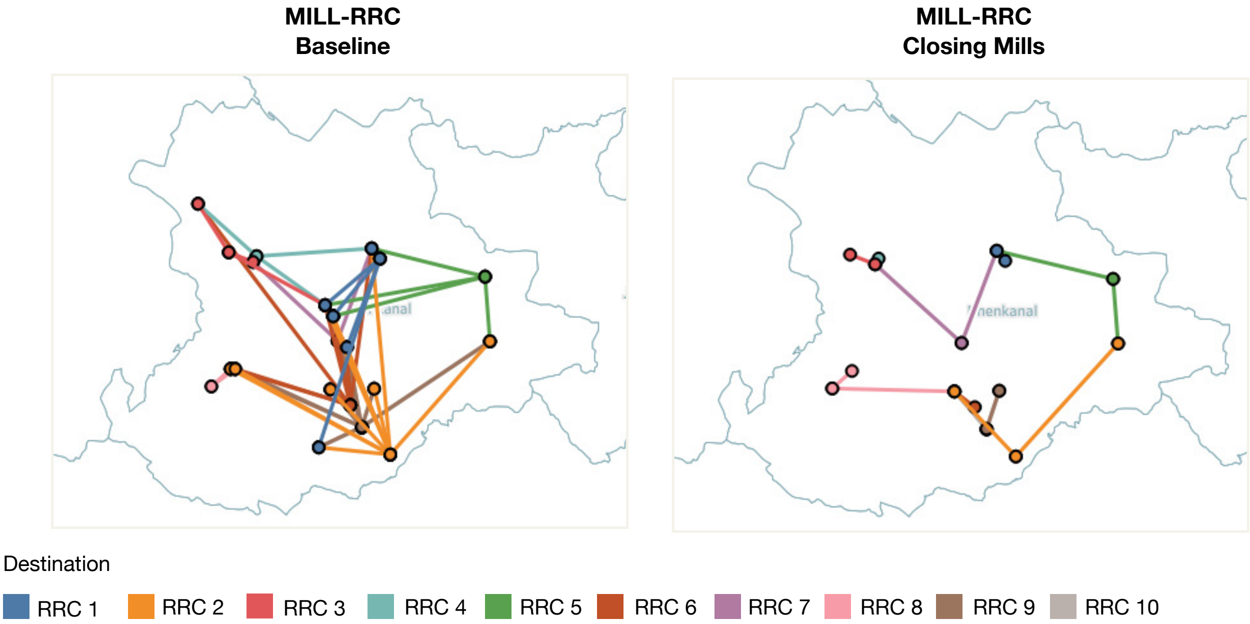


Figure 46: Geo-representation of tagging of Mill to RRC in the closing mills scenario

8.5. CHANGES REQUIRED TO IMPLEMENT THIS SCENARIO

POLICY CHANGE

- Closing mills, will require GoO to identify mills which need to be contracted instead of opting for contracting modality, where all mills which meet a minimum condition apply and receive allocation.

TECHNICAL CHANGE

- Changes to the SCMS and P-PAS databases on tagging of nodes: i.e. tagging of mills to RRCs in SCMS and tagging of PACS to mills in the P-PAS system.
- Changes to the P-PAS and SCMS databases on allocation of grains to various nodes: i.e. allocation of paddy to mills in P-PAS and rice from mills in SCMS.

OPERATIONAL CHANGE

- Changes to existing contracts/prepare new contract for the next procurement cycle for mills to accommodate transportation and other changes as a result of revised tagging and allocation.
- Changes in the tagging and volume from PACS to Mill and changes in tagging for Mill to RRC.
- Preparation of new allocation orders based on the changes in tagging of PACS to Mill and Mill to RRC. While the changes do not impact the total quantity delivered to each RRC, there are changes in the quantities received by RRC from each mill.
- Changes in the planning/execution, delivery schedules and pick up of paddy from PACS to Mill and Mill to RRC.

SCENARIO 6
CLOSING PACS

9

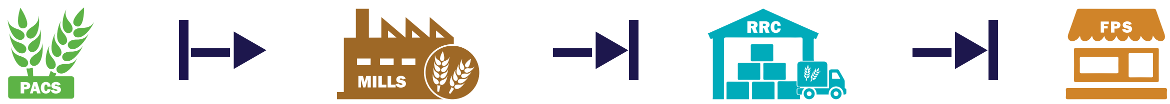
CHAPTER

SCENARIO 6.
CLOSING PACS

9.1. ABOUT THE SCENARIO

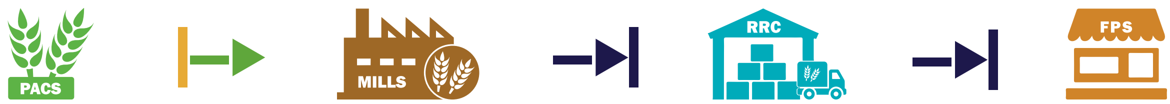
This scenario like scenario 2 optimises tagging of PACS to Mill. However, in this case the optimisation model also chooses not to procure any paddy at particular PACS, thereby choosing to close it. To make sure that enough paddy is procured to fulfil all the demand in the district, the optimiser allocated each PACS up to its maximum capacity. 12 out of the 80 PACS in the district are closed in this scenario, with and overall reduction of 5% in the total costs or Rs. 2,48,229 per month. Since, the volume of paddy allocated to each mill remains same, hence there is no impact on leg 2, 3. For leg 1 i.e. PACS to Mill, the total distance is reduced by 1,647 km resulting in reduction of 16% costs in leg 1.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: CLOSING PACS



TTC: Rs. 43,23,411 (-5%) | ADT: 78.1 KM./QTL. | ATC: 1.30 RS. PER KM./QTL.

Can be changed *Remains the same* *Can be closed*

Table 22: Summary statistics for the scenario closing PACS

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

9.2. KEY CONSTRIANTS

1. All paddy that is procured is transported to one of the mills in the district.
2. All paddy that is procured from the PACS is processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. The volumes of rice that are being transported from mills to RRCs are given by the data.
5. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
6. FPS can only be supplied by a RRC that it's connected to according to the current FPS tagging (this holds for the supply of both rice and wheat).
7. All demand for rice and wheat at every FPS must be satisfied.
8. The wheat allocation of every RRC is defined by the wheat demand of the connected FPSs.
9. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
10. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.
11. The model may choose to use the PACS up to its maximum capacity and PACS can be closed as long as the total supply of the PACS is enough to fulfil the demand.

9.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → Paddy (73,529 Qtls) → MILLS			
Baseline	15,69,794	1.09	19.51
Closing PACS	13,21,565 (-16%)	1.32 (+21%)	13.57 (-30%)
MILLS → Rice (45,000 Qtls) → RRC			
Baseline	9,09,631	0.95	19.24
Closing PACS	9,09,631	0.95	19.24
RRC → Rice (45,000 Qtls) → FPS			
Baseline	16,44,524	1.63	22.40
Closing PACS	16,44,524	1.63	22.40
FCI → Wheat (8000 Qtls.) → RRC			
Baseline	1,57,941	0.86	22.92
Closing PACS	1,57,941	0.86	22.92
RRC → Wheat (8000 Qtls.) → FPS			
Baseline	2,89,750	1.63	22.22
Closing PACS	2,89,750	1.63	22.22

Table 23: Key output KPI's for scenario closing PACS

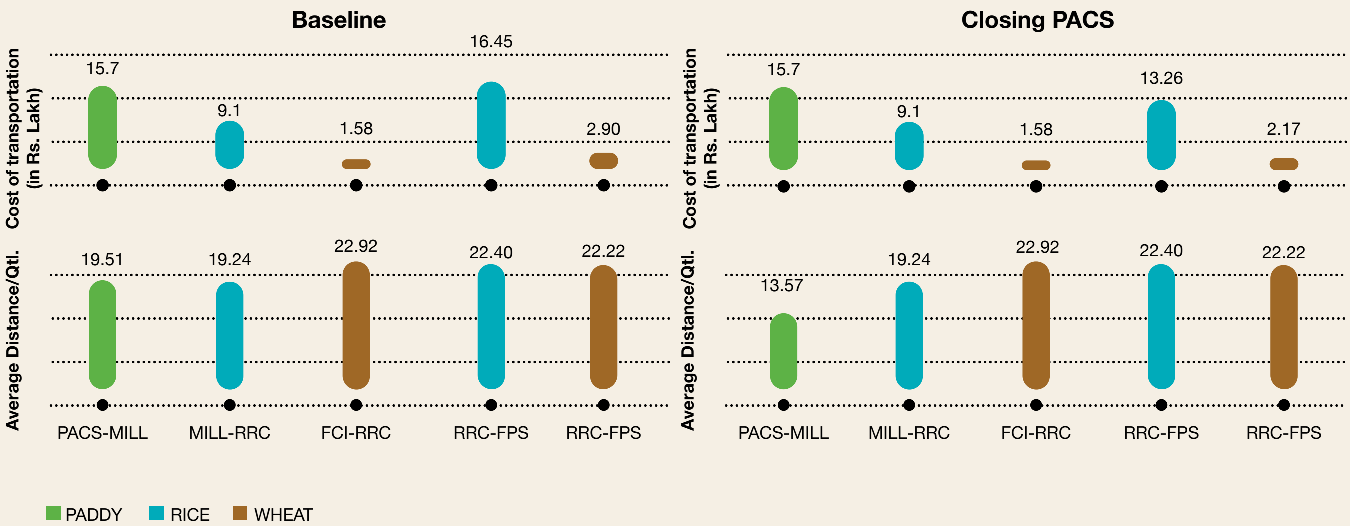


Figure 47: Total distance and costs of transportation for all legs in this scenario closing PACS

9.4. CHANGES FROM THE BASELINE

The optimal configuration in this case chooses to close 12 of the 80 PACS reducing the costs of leg 1 by 16% which is more than double of the cost savings in optimising PACS tagging scenario. The changes are restricted to leg 1 of the supply chain as there are changes only in the tagging of PACS to Mill and not in the volume of paddy allocated to each Mill.

9.4.1. OBSERVATIONS FOR LEG 1: PACS TO M ILL

9.4.1.1. TAGGING AND VOLUME

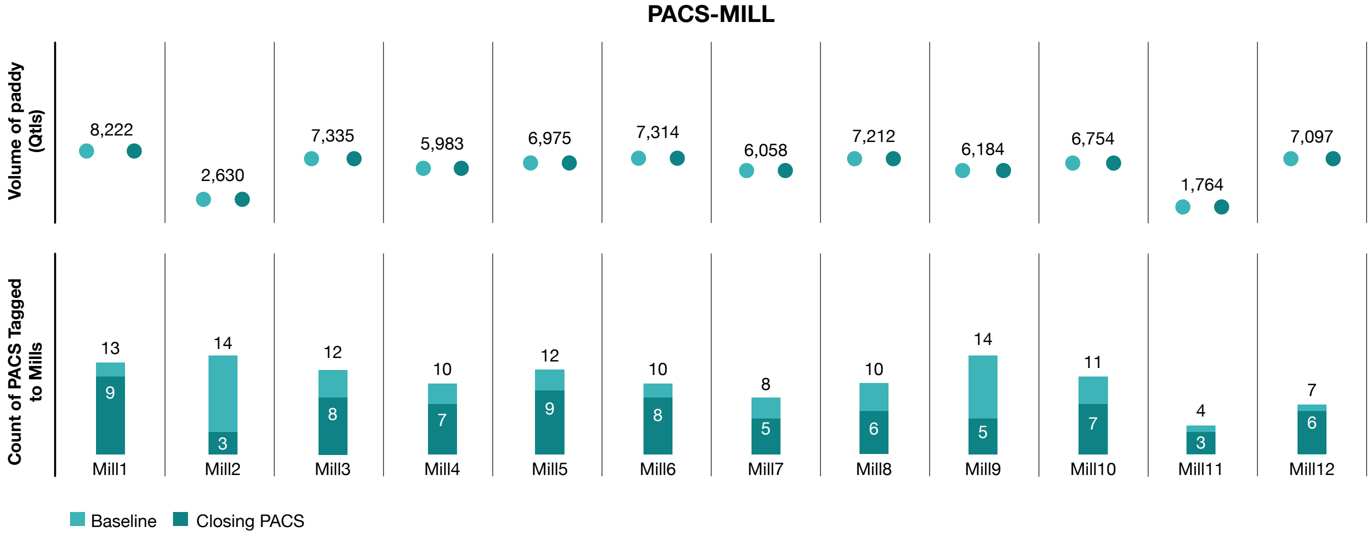


Figure 48: Tagging and volume of paddy from PACS to mills in the closing PACS scenario

- Tagging of PACS to Mill has been optimised under the given constraints. The number of nodes traversed in leg 1 have reduced from 125 to 76. (Figure 48).
- Tagging of PACS to Mill 2 (BDN Food Products) and Mill 9 (Natural Agritech Pvt. Ltd.) has shown significant decline from 14 to 3 and 5 PACS respectively.

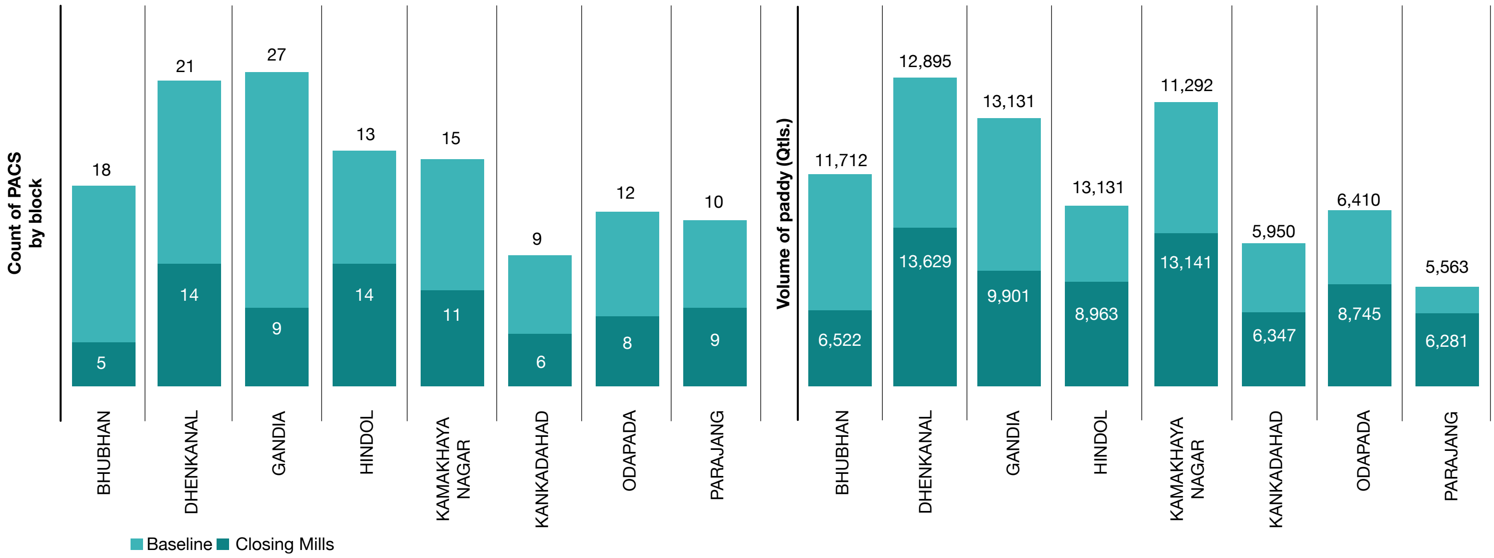


Figure 49: Changes in tagging and volume of paddy by block in the closing PACS scenario

Even though there are significant changes in tagging of PACS, the change in volume procured by block is smaller. Kankadahad, Parajang and Dhenkanal block have the least change in volume procured, while Gandia and Bhuban block have the most impact in the procured volume. (Figure 49)

9.4.1.2. DISTANCE AND COSTS

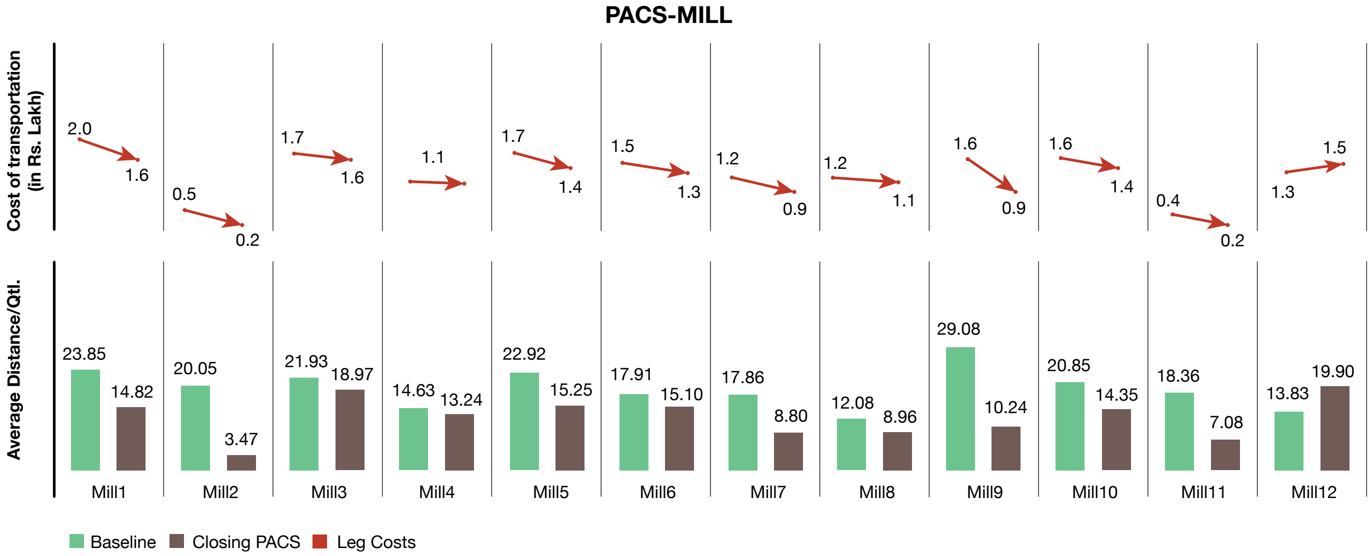


Figure 50: Distance and cost of transportation from PACS to mills for the closing PACS scenario

The cost of transportation to all the mills has reduced in leg 1 i.e.PACS to Mill. For Mill 2 (BDN Food Products) and Mill 9 (Natural Agritech Pvt. Ltd.), the average distance/Qtl had reduced significantly hence, the cost of transportation has also decreased. For Mill 12 (Tareni Agro Foods) the cost of transportation has increased, even through the number of PACS tagged has decreased from 7 to 6, because the averge distance/Qtl has increased.

9.4.2. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE CLOSING PACS SCENARIO

Figure 51, shows that the tagging for leg 1 i.e. PACS to Mill is much more optimised than in the baseline. This results in efficiency in administration due to reduction in dependencies of multiple PACS to multiple mills. As an example Mill 3 was tagged to 12 PACS in the baseline, some of which were in the extreme east. In the closing PACS scenario, Mill 3 is tagged 8 PACS all of which are closer to the Mill.

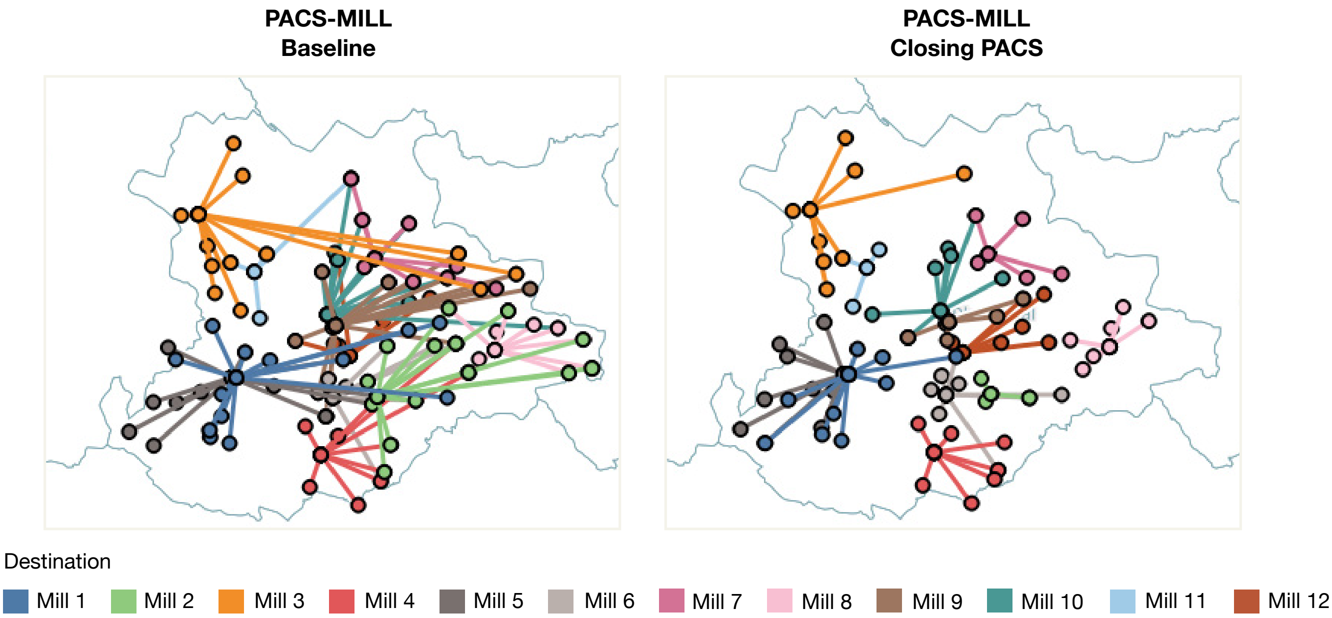


Figure 51: Geo-representation of tagging of PACS to mills in the closing PACS scenario

9.5. CHANGES REQUIRED TO IMPLEMENT THIS SCENARIO

POLICY CHANGES

- Changes in procurement policy for establishing a max distance range at which a PACS must be setup for registration and procurement from farmers.

TECHNICAL CHANGE

- Changes to the P-PAS, farmer and miller's databases on tagging of nodes: i.e. tagging of PACS to Mill.
- Changes to the P-PAS Databases on allocation of grains to each node: i.e. allocation to mills from each PACS in P-PAS.

OPERATIONAL CHANGE

- To implement the scenario would require coordination with the Department of Co-operation, for the change in number and volume of paddy procured at PACS.
- Changes in the tagging of PACS to Mill.
- Preparation of new procurement plan and allocation orders for PACS and mills for the current/new procurement cycle.
- Changes in the planning/execution, delivery schedules and pick up of paddy from PACS to mills.
- An assessment to remap registered farmers to new PACS would be required, to ensure that the impact in terms of cost and distance is minimised.
- Notification of new procurement centres through various channels and awareness activities for farmers, to ensure that they know which PACS they can now register and sell their paddy.

SCENARIO 7
CLOSING FPS

10

CHAPTER

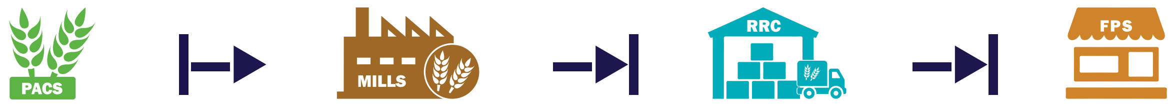
SCENARIO 7.
CLOSING FPS

10.1. ABOUT THE SCENARIO

In this scenario we quantify the costs savings and impact of closing a few FPS. The scenario is like the scenario in which we optimise the FPS tagging, with the addition that optimiser also chooses to disregard/not allocate to an FPS handling less than 40 Qtls[7] . (median volume of rice allocated to an FPS) and have another larger FPS within a 2 Km. radius. The demand of the closed FPS is then taken over the larger FPS. Since, there is only change in the tagging from RRC to FPS and the volume allocated to each RRC is constant, there is no impact on the other legs i.e. PACS to Mill and Mill to RRC. Overall, the cost savings in this scenario is 9% or Rs. 3,91,660. The optimiser closes 59 out of 565 shops, with a total cost savings of 20% in the last leg.

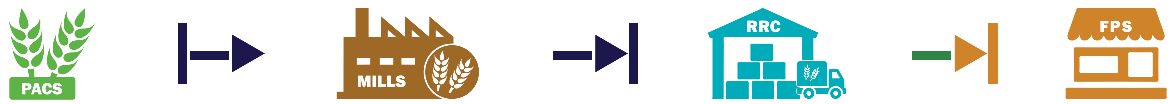
Additionally, the costs in the last leg are calculated using the per costs of transportation for leg 3 RRC to FPS (refer to Table 9) of Rs. 1.63 per Qtl. per Km. has been used.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: CLOSING FPS



TTC: Rs. 41,79,980 (-9%) | ADT: 79.5 Km./Qtl. | ATC: 1.19 Rs. per Km./Qtl.

Can be changed *Remains the same* *Can be closed*

Table 24: Summary statistics for the scenario closing FPS

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

10.2. KEY CONSTRIANTS

1. All paddy that is procured is transported to one of the mills in the district.
2. Every PACS can only supply a mill that it's connected to according to the current PACS tagging
3. All paddy that is procured from the PACS is processed by the mills.
4. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
5. The volumes of rice that are being transported from mills to RRCs are given by the data.
6. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
7. All demand for rice and wheat at every FPS must be satisfied.
8. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
9. Rice delivered from RRC to FPS is as per the FPS allocation, any remaining quantity of rice is stored for further use or transport to deficit districts.

[7] Only Rice

10.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Closing FPS	15, 69,794	1.09	19.51
MILLS → RRC: Rice (45,000 Qtls)			
Baseline	9,09,631	0.95	19.24
Closing FPS	9,09,631	0.95	19.24
RRC → FPS: Rice (45,000 Qtls)			
Baseline	16,44,524	1.63	22.40
Closing FPS	13,25,610 (-19%)	1.63	18.07 (-19%)
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Closing FPS	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Closing FPS	2,17,004 (-25%)	1.63	16.64 (-25%)

Table 25: Key output KPI's for the scenario Closing FPS

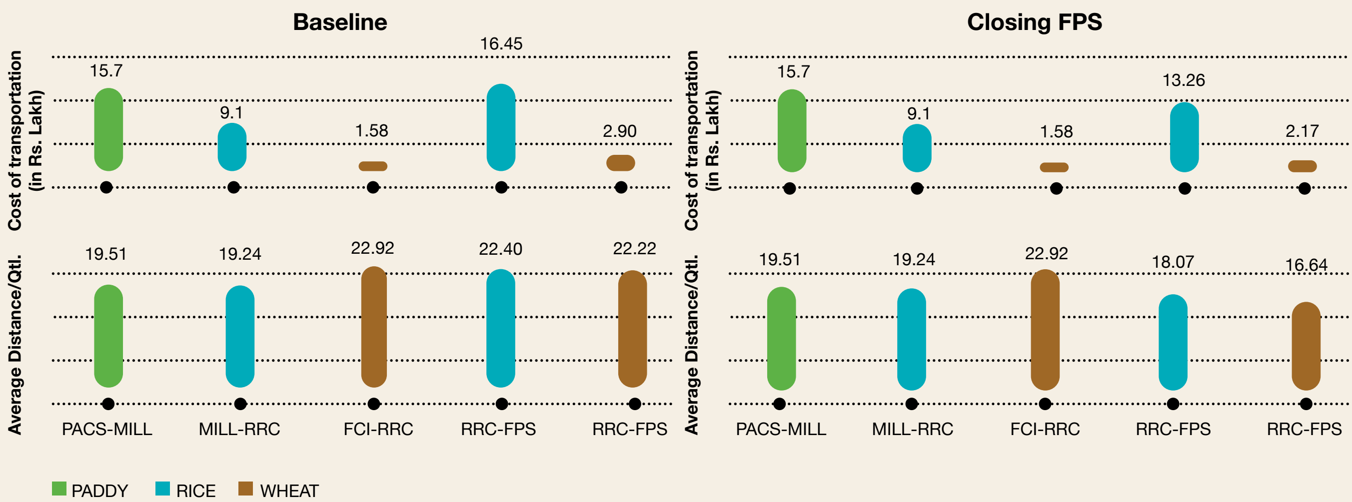


Figure 52: Total Cost of transportation and distance for all legs in the closing FPS scenario

10.4. CHANGES FROM THE BASELINE

This scenario results in the closing down of 59 out of 565 FPS, resulting in an overall cost savings of 9% or Rs. 3,91,560 per month in transportation costs. The results are similar to scenario 4: optimise FPS tagging, because the demand of the closed shops is shifted to the nearest larger shop and in both cases distance is optimised. All the changes are restricted to the last leg i.e. RRC to FPS and the transportation costs are derived using the average calculated rate of Rs. 1.63 per Km. per Qtl. based on current costs.

10.4.1. OBSERVATIONS FOR LEG 3: RRC TO FPS

10.4.1.1. TAGGING AND VOLUME

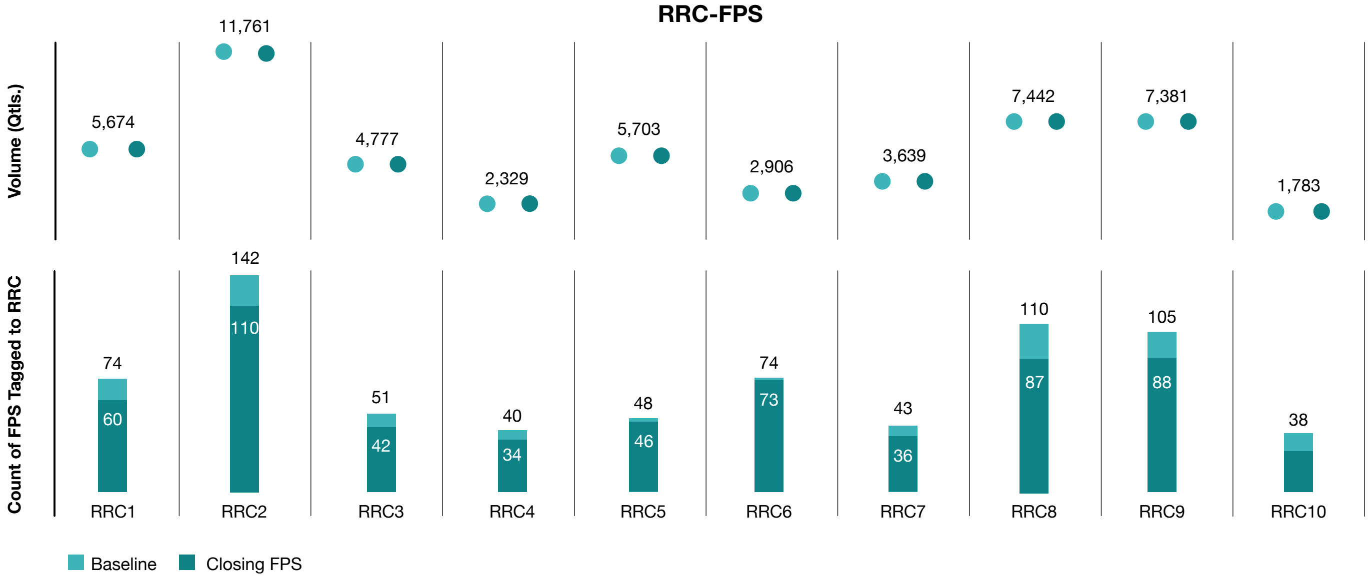


Figure 53: Changes in the tagging and volume from RRCs to FPSs in the scenario closing FPS

- Figure 53 describes the changes in tagging of FPS to RRC. While, the number of FPS tagged to RRC 2 (Baladiabandha) have reduced considerably, there are RRCs such as RRC 5 (Bhubhan) and RRC 6 (Dhenkanal), where the total number of FPS tagged has not chnaged in the new scenario.
- There is no change in the total volume from each RRCs in this scenario. A few examples of changes in volume flowing to each block in the RRC to FPS leg is shown in figure 54.

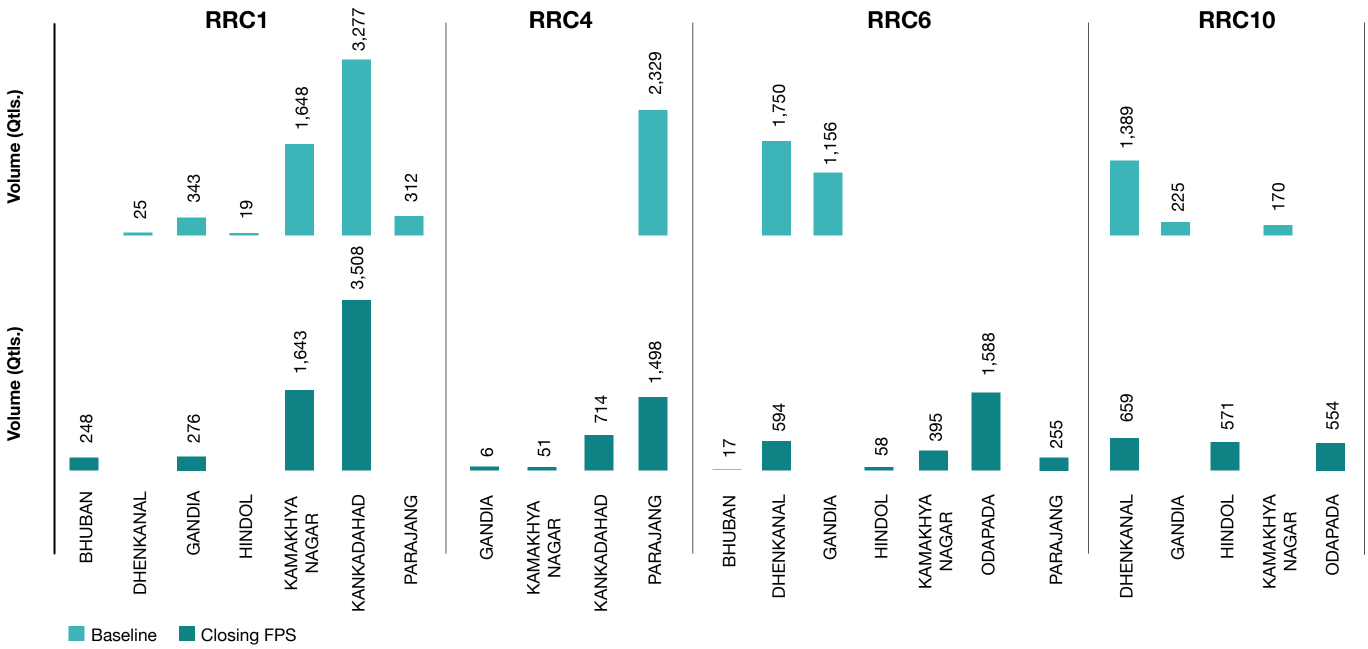


Figure 54: Changes in volume of rice and wheat from RRC to FPS(block) in the closing FPS scenario

10.4.1.2. DISTANCE AND COSTS

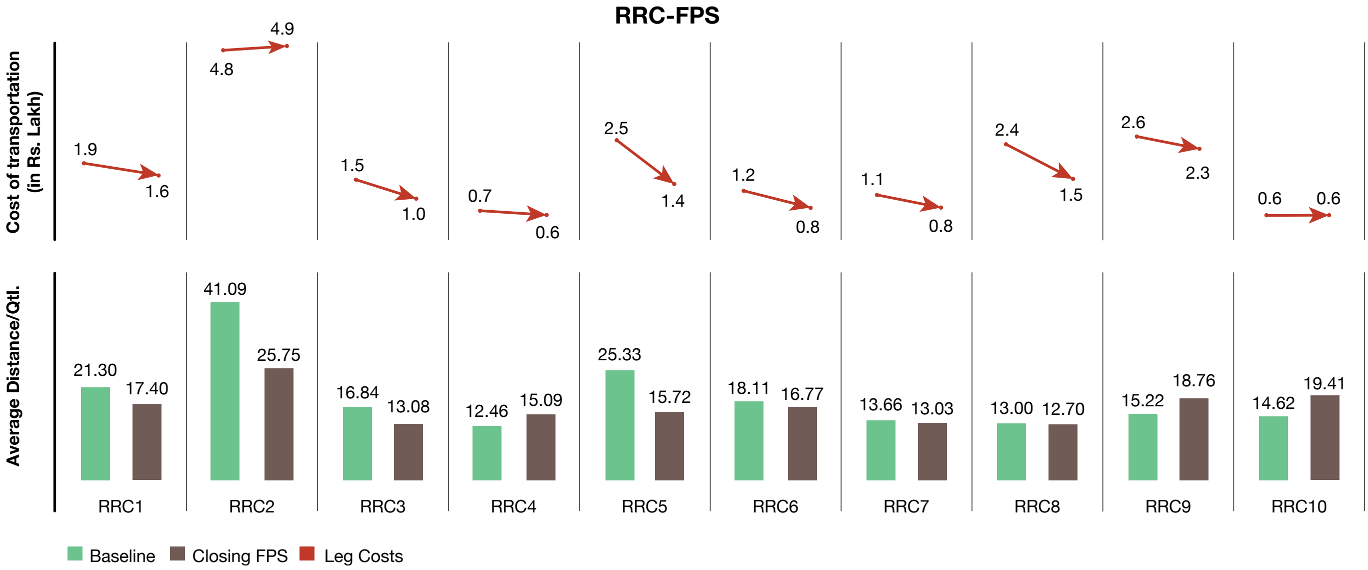


Figure 55: Average distance travelled and total cost of transportation in the closing FPS scenario (Rice and Wheat)

Figure 55, shows the average distance/Qtl and the cost of transportation for Leg 3 i.e. RRC to FPS. Overall the cost of transportation has reduced by 20% in this leg.

10.4.1.3. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE CLOSING FPS SCENARIO

Geotagging from RRC to FPS for rice is described in Figure 56. As can be seen the tagging is optimised. For example, RRC2 was tagged to 142 FPS in the baseline; in the closing FPS scenario the tagging of FPS is reduced to 110 ensuring that movement of grains from east to west is reduced and that it is much more cohesive.

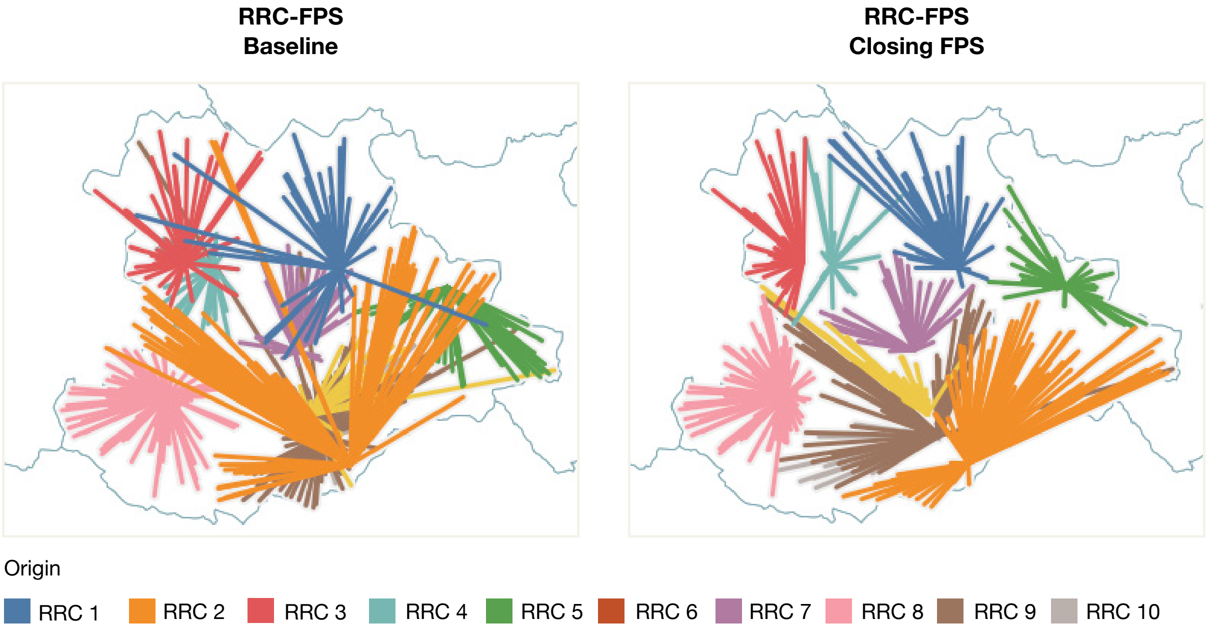


Figure 56: Geo-representation of tagging from RRC to FPS in the closing FPS scenario

10.5. CHANGES REQUIRED TO IMPLEMENT THE SCENARIO

POLICY CHANGES

- Classification of Supply Zones in the Food Security Rules and assigning of responsibilities.
- Revision in the methodology for contracting of transporters including contracting terms, transportation rate etc. to accommodate recommendation to move from per Qtl. rate to per Qtl. per Km. rate for the last leg i.e. RRC to FPS.

TECHNICAL CHANGE

- Changes to the SCMS and FPS Automation systems on tagging of nodes: i.e. tagging of RRC to FPS for allocation, movement and receipt of grains.

OPERATIONAL CHANGE

- Contracting of new Transport agents (L2 transporters) or changes to existing contracts to accommodate changes in rates of transportation, allocation and tagging.
- Preparation of new allocation orders based on the changes in tagging of RRC to FPS.
- Close FPS which meet the constraint and are chosen to be closed by the optimisation model.
- Changes in the planning/execution, delivery schedules and pick up of rice and wheat from RRC's to FPS.

SCENARIO 8
FULLY OPTIMISED WITH
CAPACITY CONSTRAINT

11

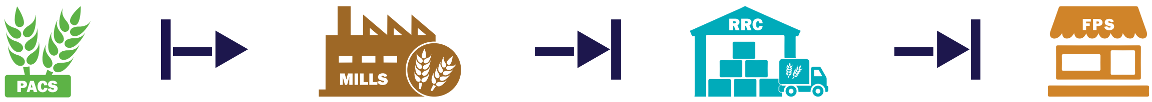
CHAPTER

SCENARIO 8.
FULLY OPTIMISED WITH CAPACITY CONSTRAINT

11.1. ABOUT THE SCENARIO

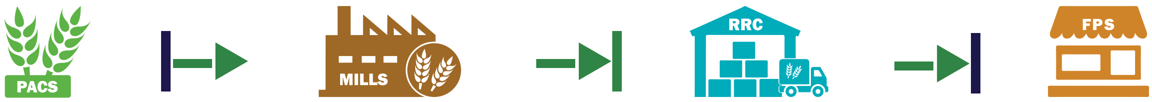
In this scenario, the optimisation model assumes that the volume that travels between all nodes (PACS, Mill, RRC, FPS) can be changed, without any change in the total allocation to the node. This ensures that the impact on the individual locations is minimal. The efficiency gains in this scenario are based on optimising the tagging of the PACS to Mill, Mill to RRC and RRC to FPS legs simultaneously and changing the volumes that travel between these leg, without change in the total allocation at the final node. This scenario results in savings of 6% in leg 1, 17% in leg 2 and 19% in leg 3 which results in an overall saving of 14% or Rs. 6,34,096. For leg 3 i.e. RRC to FPS the costs are calculated using the average costs that were incurred in the baseline which is Rs. 1.63 per Qtl. per Km (refer table 9).

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: FULLY OPTIMISED WITH CAPACITY CONSTRAINT



TTC: Rs. 39,37,544 (-14%) | ADT: 73.3 Km./Qtl. | ATC: 1.24 Rs. per Km./Qtl.

Can be changed *Remains the same* *Can be closed*

Table 26: Summary statistics for fully optimised with capacity constraints scenario

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

11.2. KEY CONSTRIANTS

1. All paddy that is procured is transported to one of the mills in the district.
2. All paddy that is procured from the PACS is processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
5. All demand for rice and wheat at every FPS must be satisfied.
6. All wheat demand in the district is fulfilled from FCI (Dhenkanal).
7. All volume flowing through the RRCs, Mills and FPS should remain the same as in the baseline.

11.3. KEY PERFORMANCE INDICATORS

Route	Scenario	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)	Baseline	15,69,794	1.09	19.51
	Fully Optimised (Capacity Constrained)	14,82,373 (-6%)	1.12 (+3%)	17.92 (-8%)
MILLS → RRC: Rice (45,000 Qtls)	Baseline	9,09,631	0.95	19.24
	Fully Optimised (Capacity Constrained)	7,53,663 (-17%)	1.03 (+8%)	14.63 (-24%)
RRC → FPS: Rice (45,000 Qtls)	Baseline	16,44,524	1.63	22.40
	Fully Optimised (Capacity Constrained)	13,265,471 (-19%)	1.63	18.08 (-19%)
FCI → RRC: Wheat (8000 Qtls.)	Baseline	1,57,941	0.86	22.92
	Fully Optimised (Capacity Constrained)	1,57,941	0.86	22.92
RRC → FPS: Wheat (8000 Qtls.)	Baseline	2,89,750	1.63	22.22
	Fully Optimised (Capacity Constrained)	2,17,095 (-25%)	1.63	16.65 (-25%)

Table 27: Key output KPI's for scenario fully optimised with capacity constraints

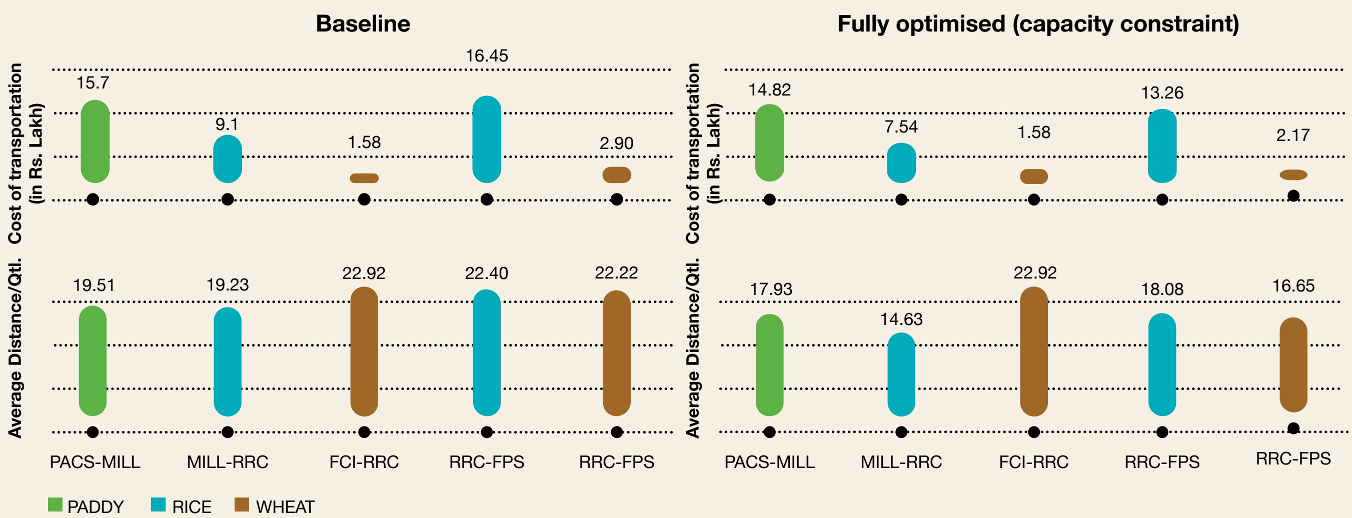


Figure 57: Total cost and average distance/Qtl in all legs for the fully optimised with capacity constraint scenario

11.4. CHANGES FROM THE BASELINE

Tagging and volume between various nodes in leg 1, 2, 3 has been changes, without change in the total allocation to each node. Overall the average/distance per Qtl. has reduced in all legs. For the FCI to RRC leg no change has been noted since all 10 RRC's are tagged to FCI Dhenkanal and without any change in total wheat volume at the individual RRCs, tagging cannot be changed.

11.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

11.4.1.1. TAGGING AND VOLUME

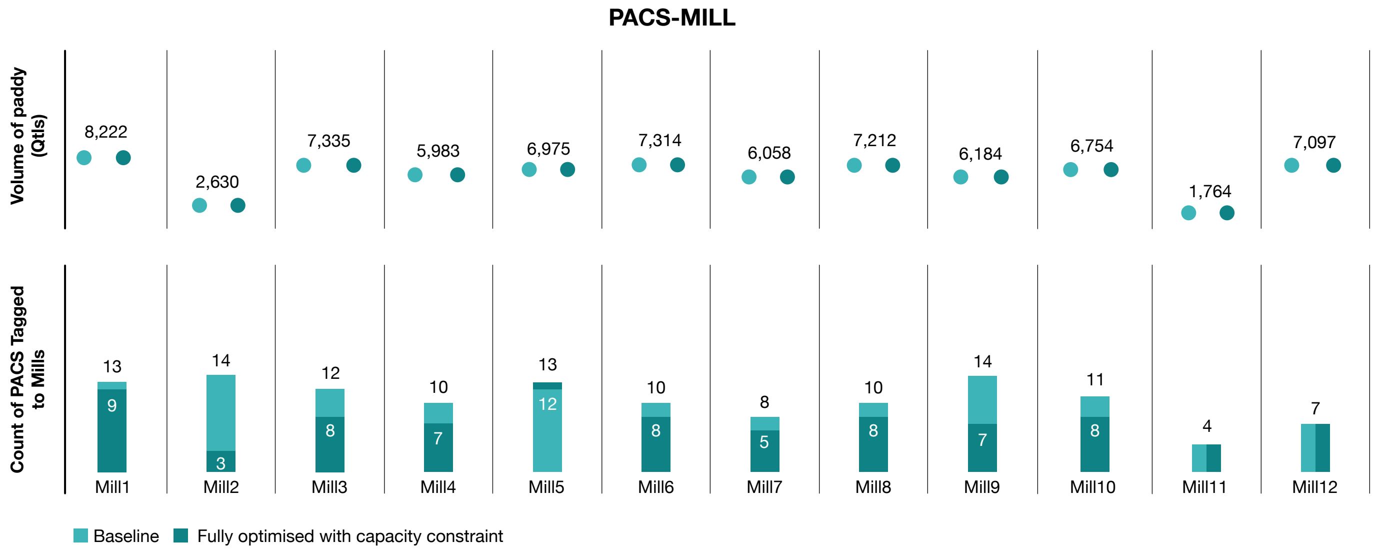


Figure 58: Tagging and Volume from PACS to mills in the fully optimised with capacity constraint scenario

- The tagging of the PACS in this scenario is the same as in scenario 2: Optimising PACS tagging (Refer Figure 16) and the tagging has changed for 52 out of 80 PACS. (Figure 58)
- There is no change in the total volume allocated to mills, even though there are changes to the volume from each PACS to each mill.
- Figure 59, describes a few examples of chnages in volume from PACS to Mills for Mill1, 2 and 9 i.e. Annapurna Rice Mill, BDN Food Products and Natural Agritech Pvt. Ltd.

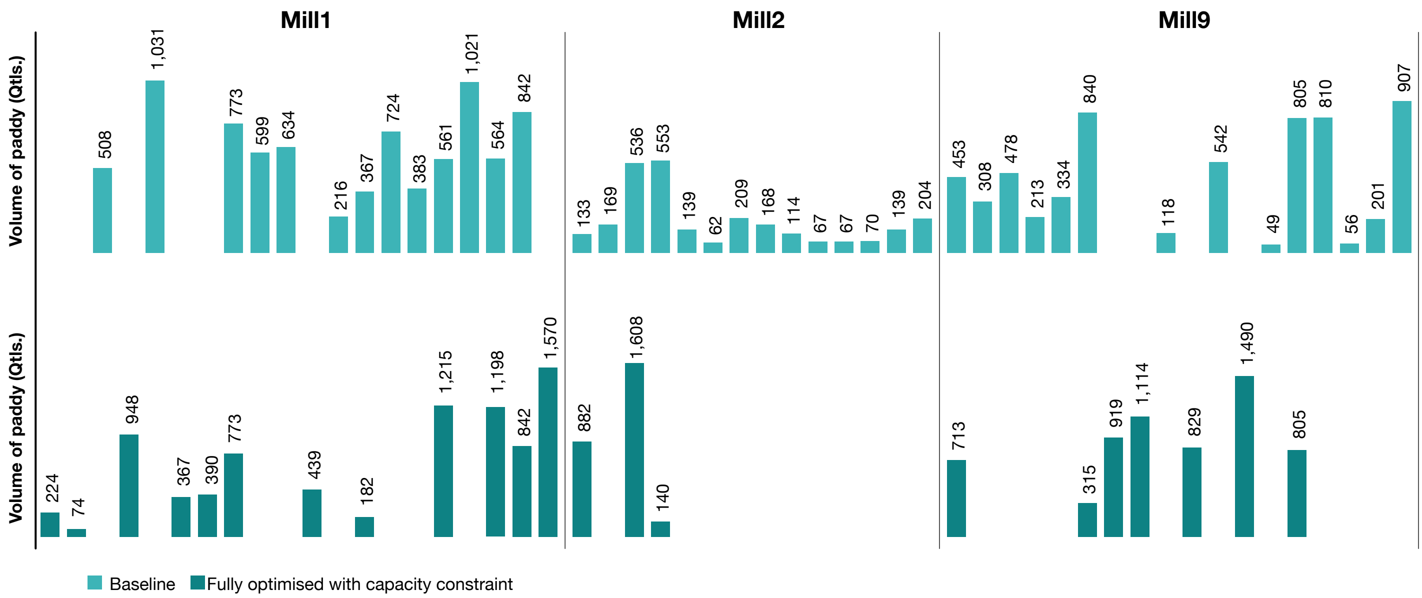


Figure 59: Changes in volume of paddy from PACS to mills (example) in the fully optimised with capacity constrained scenario

11.4.1.2. DISTANCE AND COSTS

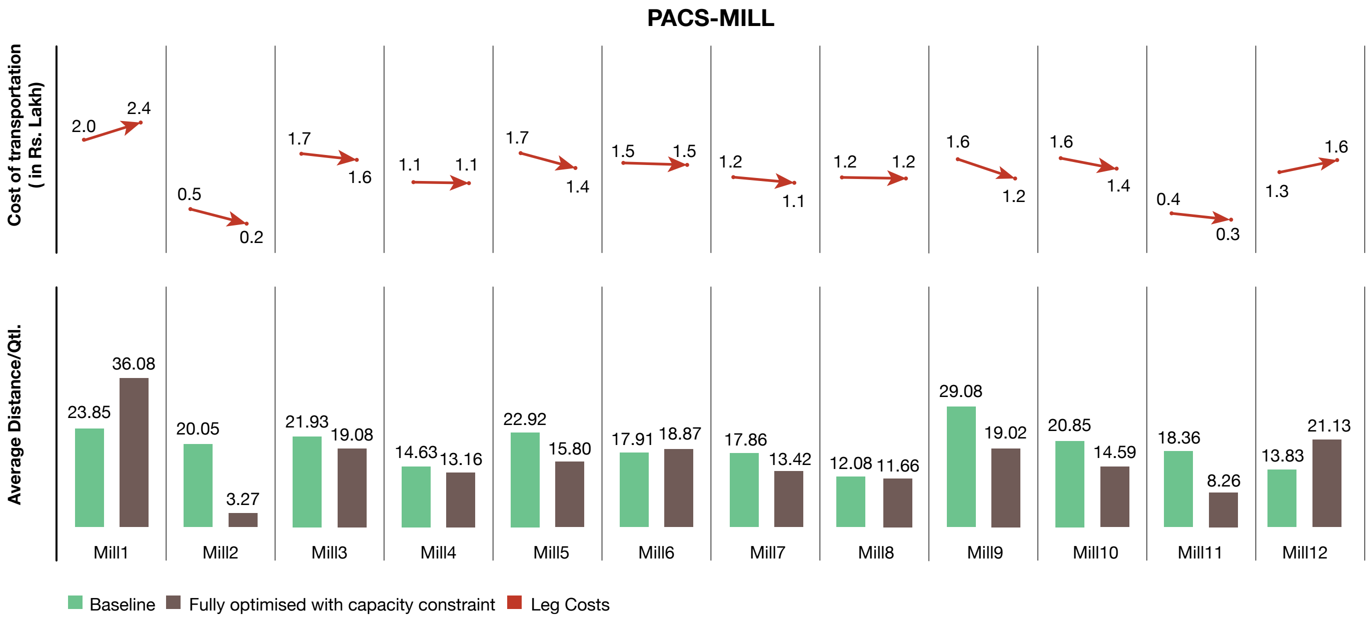


Figure 60: Average distance/Qtl. and cost of transportation from PACS to mills in the fully optimised with capacity constrained scenario

Figure 60, describes the cost of transportation and the total distance between PACS and mills in the fully optimised with capacity constrained scenario. Cost of transportation for Mill 1 (Annapurna Rice Mills) and 12 (Tareni Agro Foods) has been increased since the average distance/Qtl. travelled from PACS to these mills has increased. For all other mills, the total cost of transportation has reduced.

11.4.2. OBSERVATIONS FOR LEG 2: MILL TO RRC

11.4.2.1. TAGGING AND VOLUME

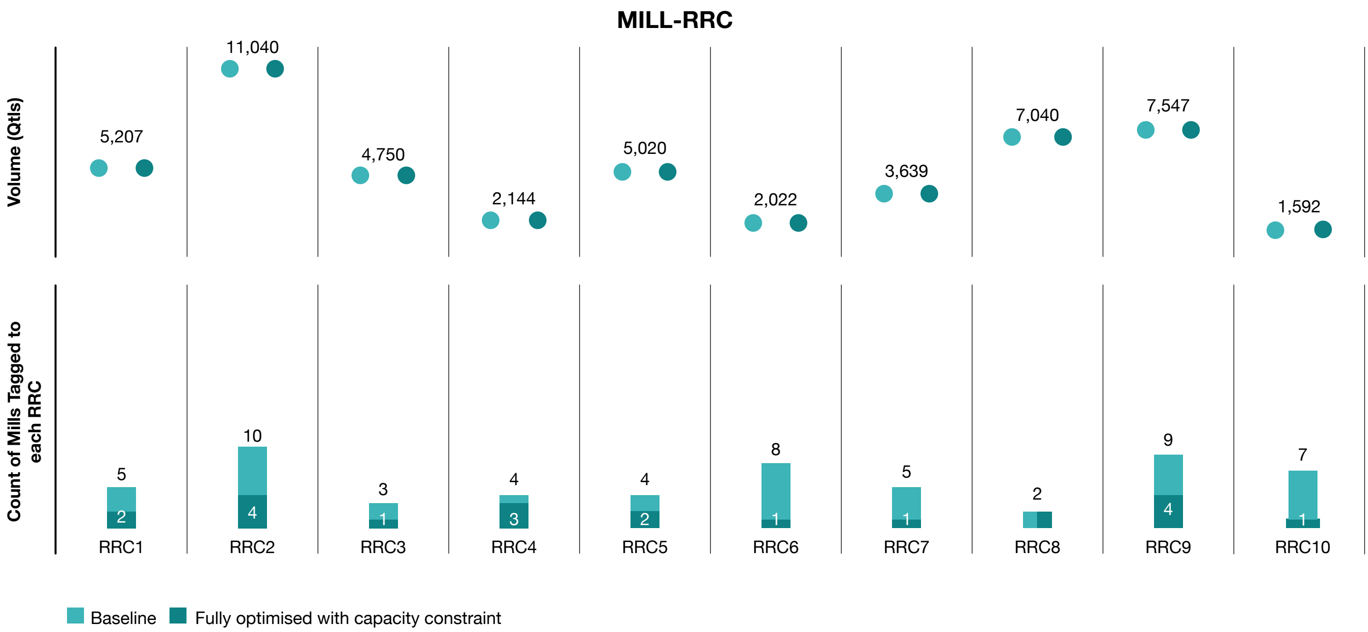


Figure 61: Tagging and volume of rice from mills to RRC in the fully optimised with capacity constrained scenario

- Tagging between mills to RRCs has been optimised, with number of nodes traversed reduced from 57 to 21. (Figure 61)
- This scenario is similar to optimise Leg 1 & 2 scenario, as an example, tagging of mills to RRC 6 has been reduced from 8 to1 in both scenario’s.

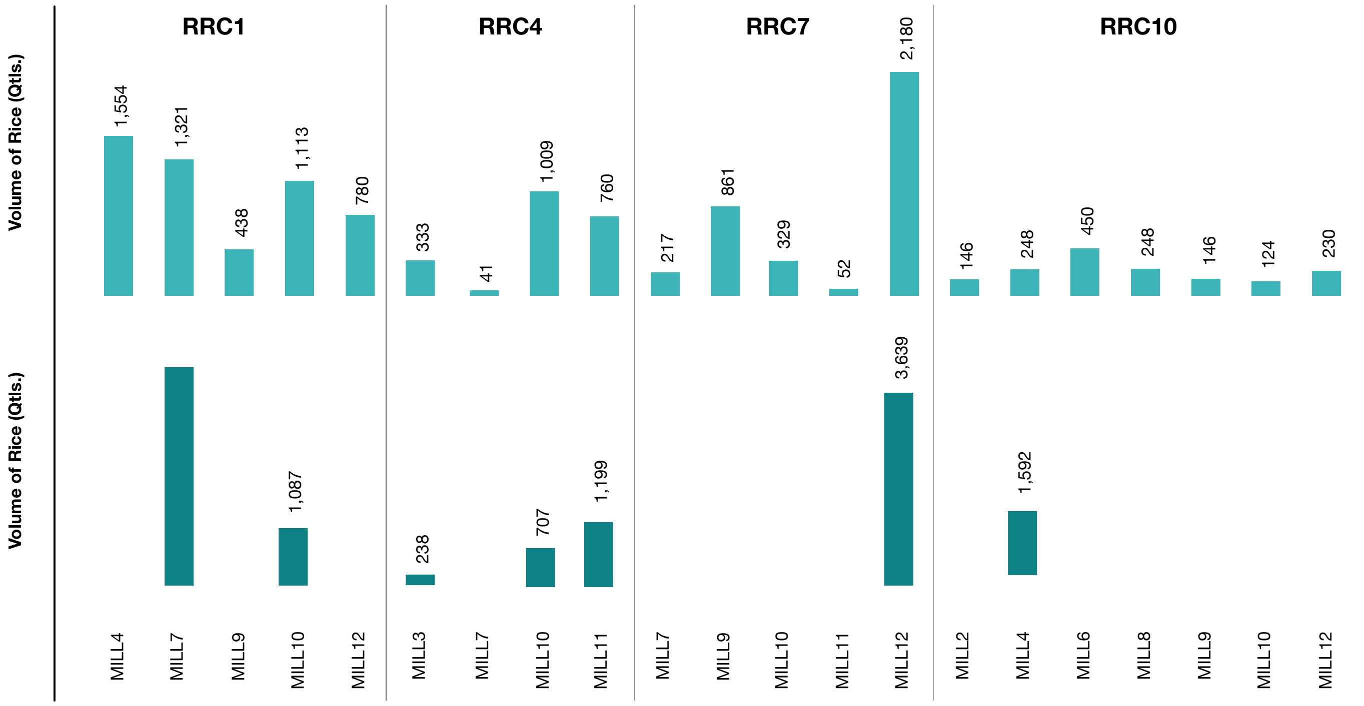


Figure 62: Changes in volume of rice from mills to RRC in the fully optimised with capacity constrained scenario

The total volume allocated to each RRC has not changed but the volume of rice between each mill and RRC has changed. Examples of the changes in volume between mills and RRC are shown in Figure 62.

11.4.2.2. DISTANCE AND COSTS

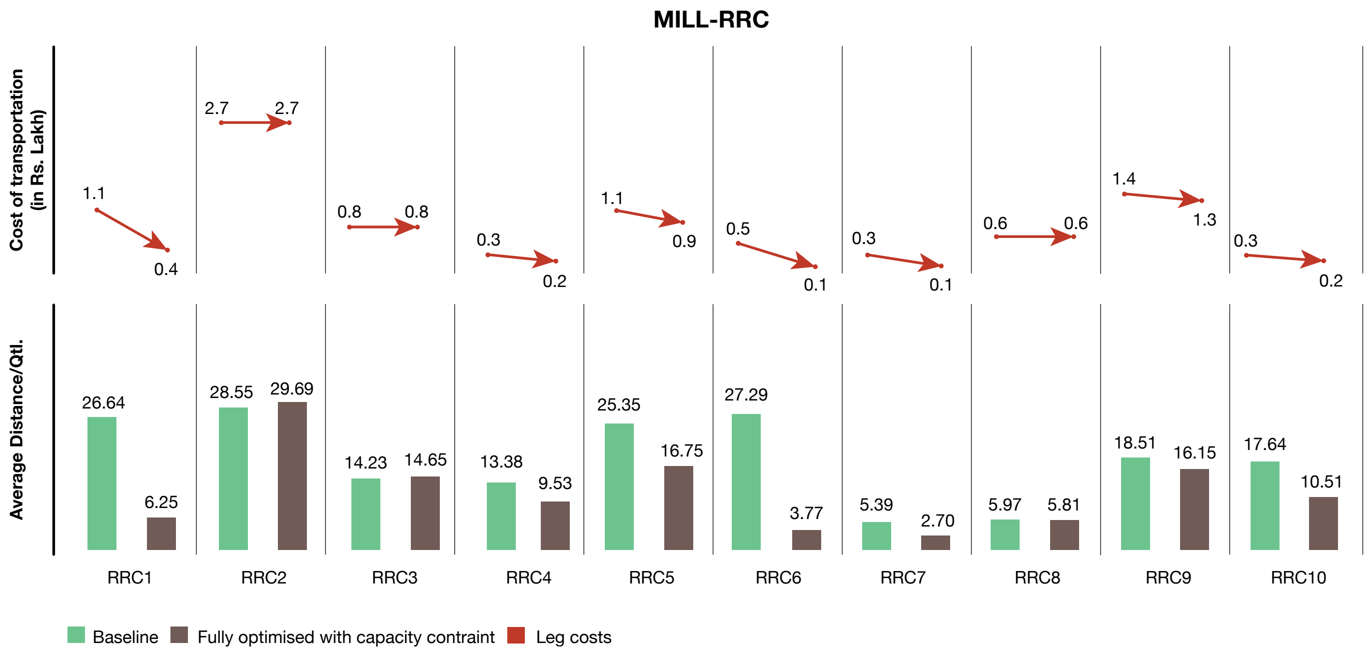


Figure 63: Average distance/Qtl. and costs from mills to RRC in the in fully optimised with capacity constrained scenario

The cost of transportation has decreased for all nodes in the Mill to RRC leg, except for RRC 2 (Baladiabandha) and RRC 3 (Barihapur), because for these RRCs the average cost per Qtl. has increased.

(Please note: minor variations in costs may not be visible in the figure, since the costs are represented in lakh Rs.)

11.4.3. OBSERVATIONS FOR LEG 3: RRC TO FPS

11.4.3.1. TAGGING AND VOLUME

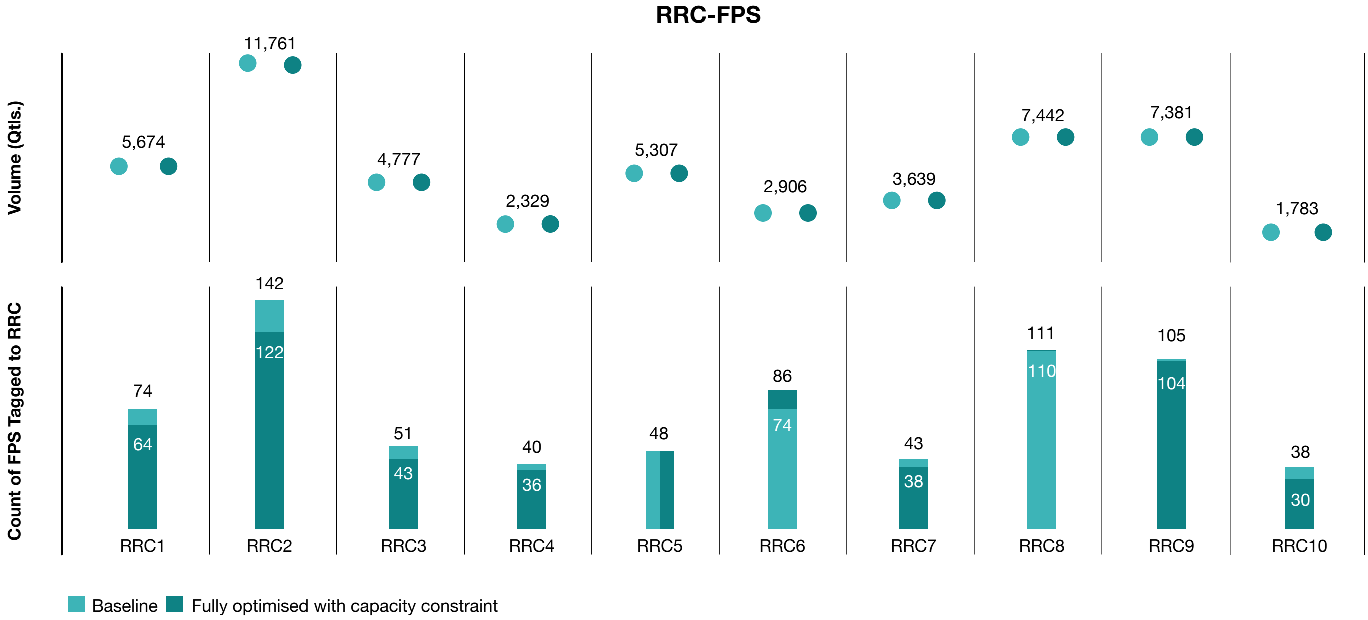


Figure 64: Tagging of volume from RRC to FPS in the fully optimised with capacity constrained scenario

- Tagging of 356 out of the 565 FPS has been changed, which is same as in the optimising FPS tagging scenario
- There is no change in the total volume from each RRC. Figure 65 describes the changes in volume from each RRC to each block. Example: RRC1 (Badasuanlo) was serving Parajang block in baseline, but in the fully optimised with capacity constraint scenario, it is not tagged to that block.

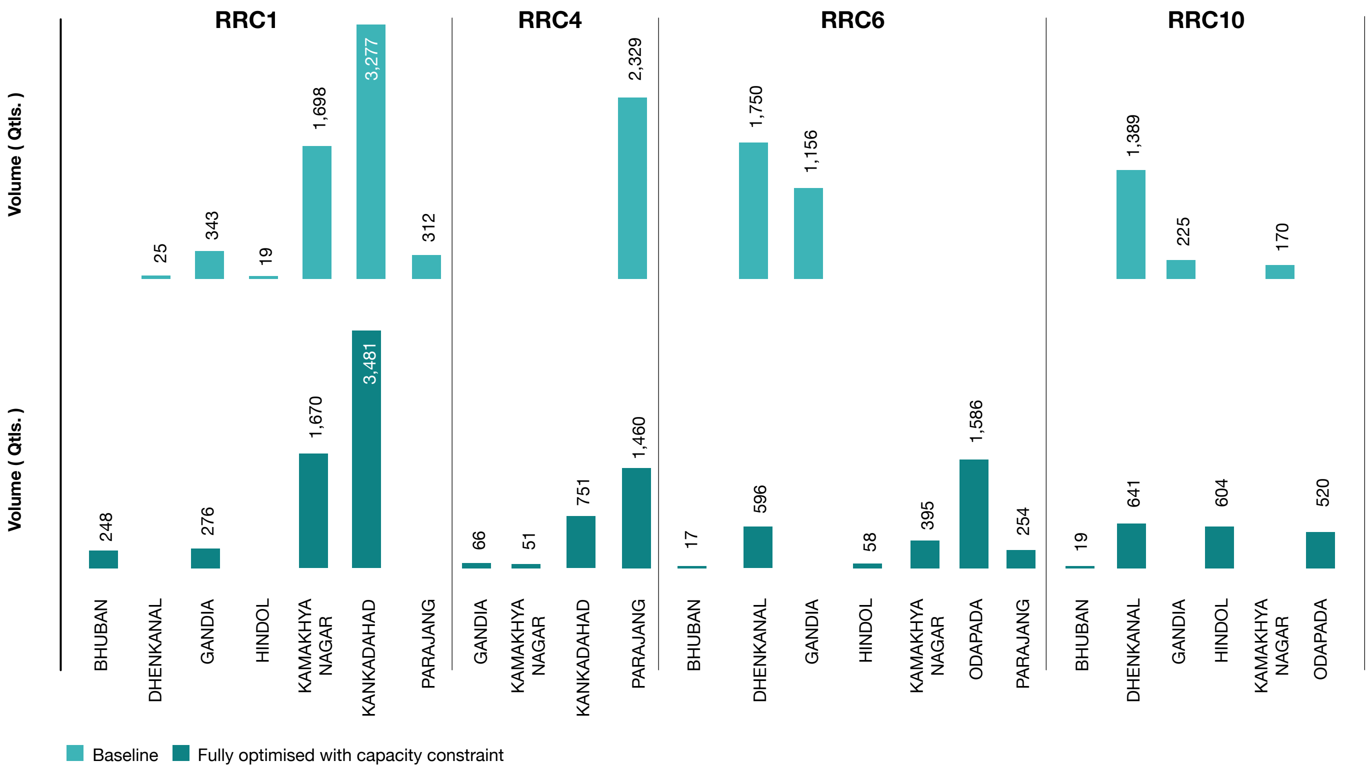


Figure 65: Changes in volume from RRC to FPS (block) in the fully optimised with capacity constraint scenario

11.4.3.2. DISTANCE AND COSTS

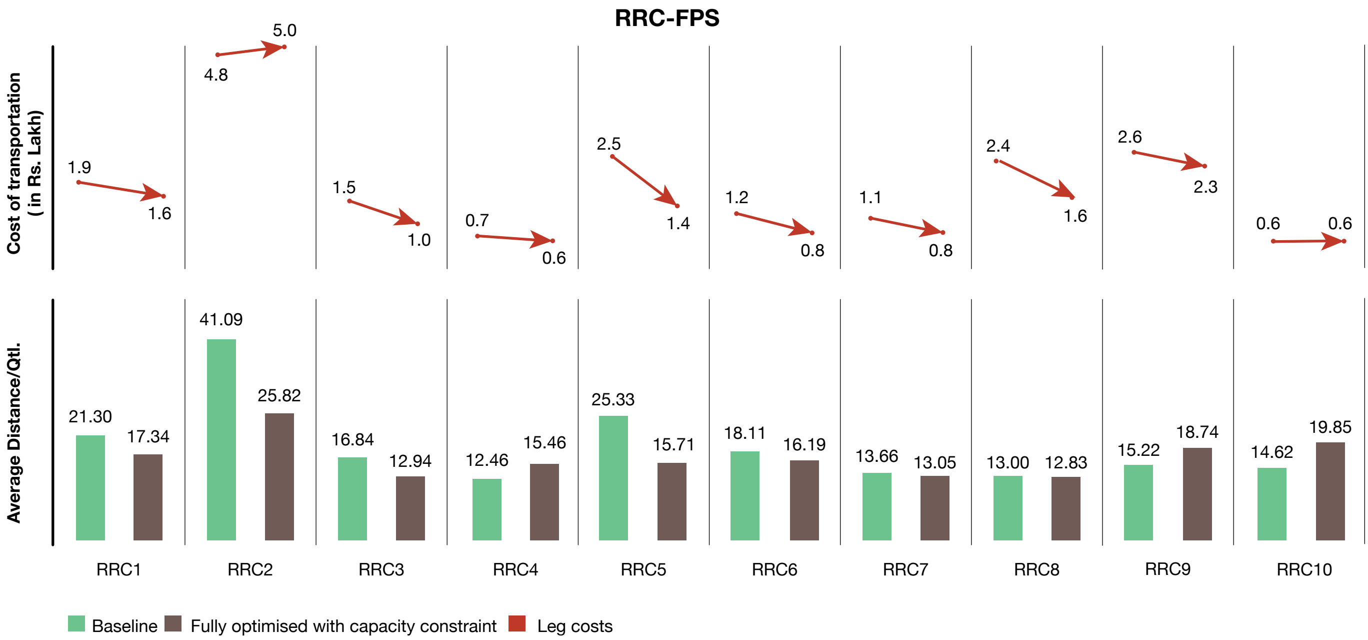


Figure 66: Average distance/Qtl. and cost of transportation from RRC to FPS in the fully optimised with capacity constrained scenario

The total cost of transportation has reduced by 20% in leg 3 i.e RRC to FPS. The costs in this leg are calculated based on average cost per Qtl per Km. derived from the baseline costs.

11.4.4. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE FULLY OPTIMISED WITH CAPACITY CONSTRAINED SCENARIO

Tagging between all nodes of the supply chain PACS to Mill, Mill to RRC, RRC to FPS has been optimised in this scenario. We can observe that the tagging from PACS to Mills is very similar to scenario 2: Optimising PACS tagging (refer figure 23), while the tagging from RRC to FPS is very similar to the optimising FPS tagging scenario (refer figure 38).

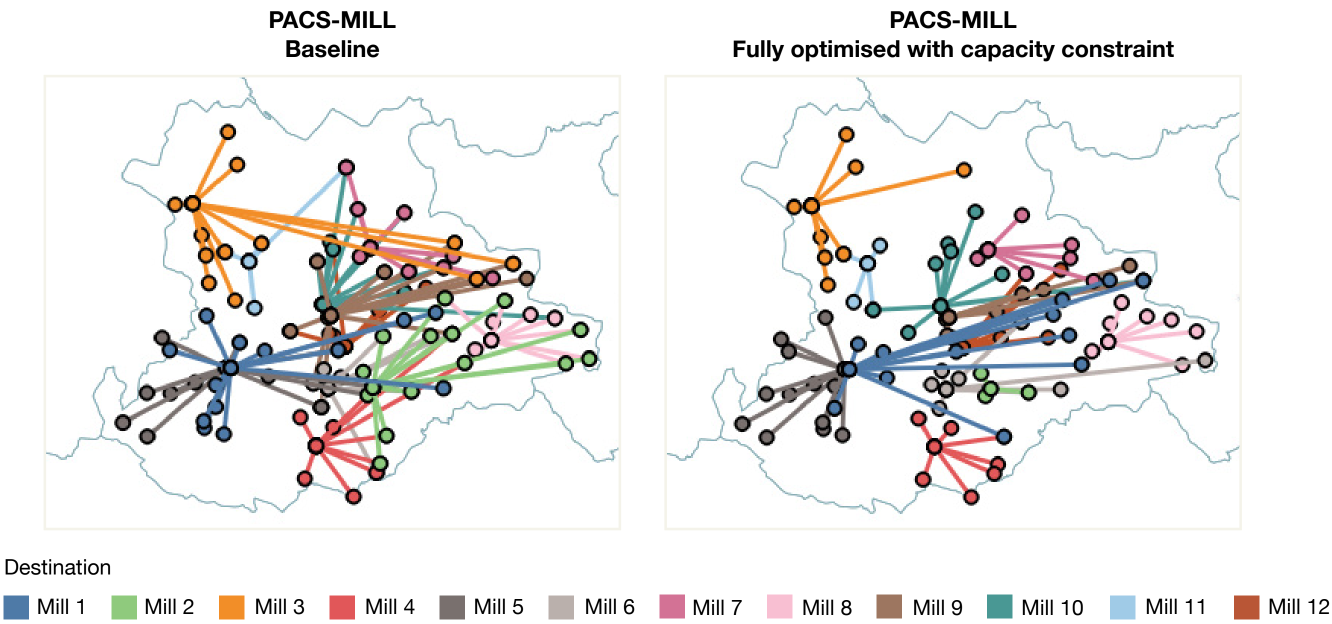


Figure 67: Geo-representation of tagging of PACS to mills in the fully optimised with capacity constrained scenario

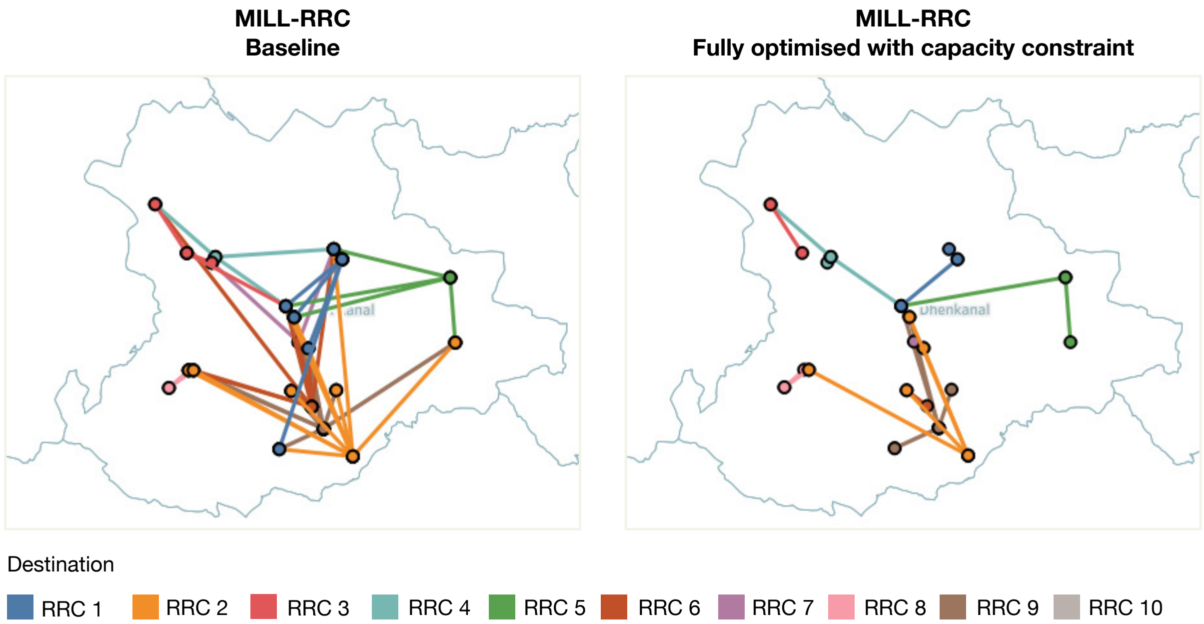


Figure 68: Geo-representation of tagging of mills to RRC in the fully optimised with capacity constrained scenario

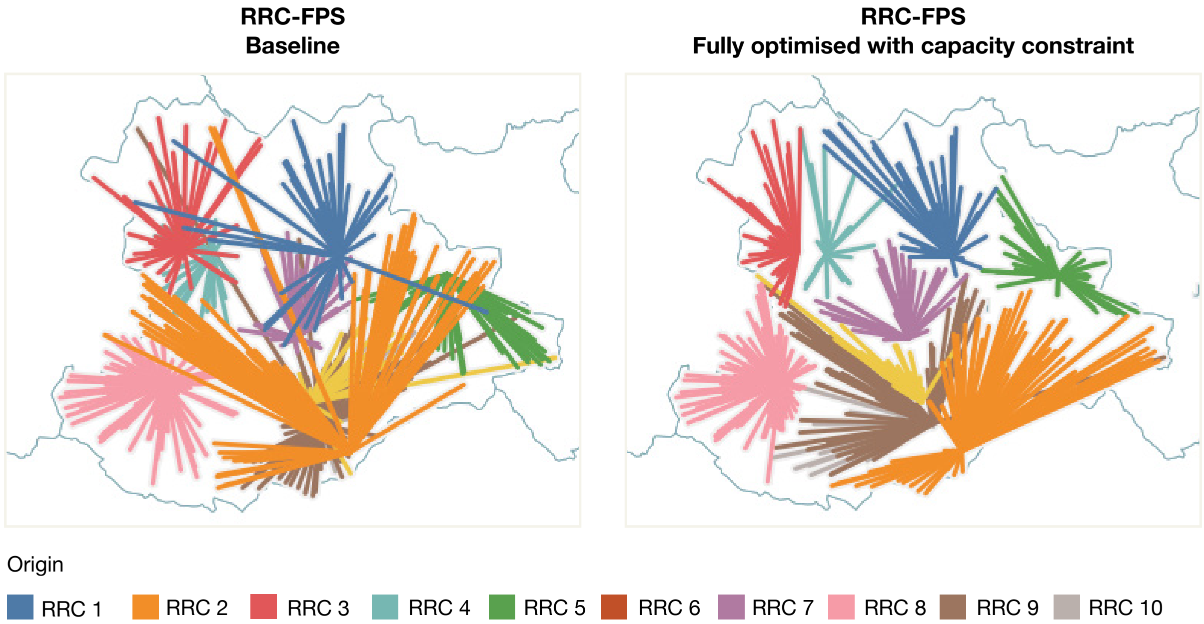


Figure 69: Geo Representation of Tagging of RRC to FPS in the fully optimised with capacity constrained scenario

11.5. CHANGES REQUIRED TO IMPLEMENT THE SCENARIO

POLICY CHANGES

- Classification of Supply Zones in the Food Security Rules and assigning of responsibilities.
- Revision in the methodology for contracting of transporters including contracting terms, transportation rate etc. to accommodate recommendation to move from per Qtl. rate to per Qtl. per Km. rate for the last leg i.e. RRC to FPS.

TECHNICAL CHANGE

- Changes to the SCMS and P-PAS databases on tagging of nodes: i.e. tagging of mills to RRCs and RRCs to FPS in SCMS and tagging of PACS to mills in the P-PAS system

OPERATIONAL CHANGE

- Contracting of new Transport agents (L1 and L2 transporters) or changes to existing contracts to accommodate changes in rates of transportation, allocation and tagging.
- Preparation of new allocation orders based on the changes in tagging of RRC to FPS.
- Changes in the planning/execution, delivery schedules and pick up of paddy, rice and wheat between the various nodes.

SCENARIO 9
FULLY OPTISMISED WITH
CAPACITY CONSTRAINT +15%

12

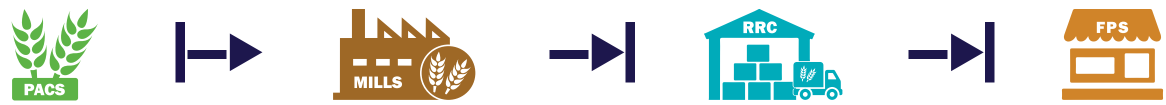
CHAPTER

SCENARIO 9.
FULLY OPTIMISED WITH CAPACITY CONSTRAINT (+15%)

12.1. ABOUT THE SCENARIO

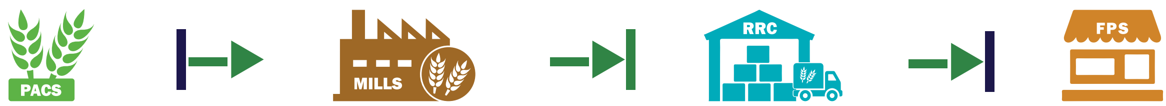
This scenario in addition to changing the tagging between all the nodes of the supply chain i.e PACS to Mill, Mill to RRC and RRC to FPS also allows the optimiser to increase the allocation to various nodes by 15%. This means that every mill can have 15% more volume allocated to it and every RRC can have 15% more throughput than was the case in the baseline scenario. This allows the optimiser to explore more possibilities to optimise the costs and distance between various nodes. The rationale to use 15% was to marginally increase the allocation, while ensuring that it is practical to do so. This scenario results in savings of 9% in leg 1, 27% in leg 2 and 30% in leg 3 which results in overall savings of 21% or Rs. 9,65,352 per month. For leg 3 i.e. RRC to FPS the costs are calculated using the average costs that were incurred in the baseline, which is Rs. 1.63 per Qtl. per Km (refer table 9).

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: FULLY OPTIMISED WITH CAPACITY CONSTRAINT + 15%



TTC: Rs. 36,06,288 (-21%) | ADT: 67.8 Km./Qtl. | ATC: 1.28 Rs. per Km./Qtl.

Can be changed *Remains the same* *Can be closed*

Table 28: Summary statistics for the scenario fully optimised with capacity constraint +15%

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

12.2. KEY CONSTRIANTS

1. All paddy that is procured must be transported to one of the mills in the district.
2. All paddy that is procured from the PACS must be processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
5. All demand for rice and wheat at every FPS must be satisfied.
6. All wheat demand flows into the district at the FCI (Dhenkanal).
7. All mills and RRCs can process maximum 15% more than they did in the baseline scenario.

12.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → MILLS: Paddy (73,529 Qtls)			
Baseline	15,69,794	1.09	19.51
Fully Optimised (CapacityConstrained +15%)	14,21,323 (-9%)	1.19 (+9%)	16.20 (-17%)
MILLS → RRC: Rice (45,000 Qtls)			
Baseline	9,09,631	0.95	19.24
Fully Optimised (Capacity Constrained +15%)	6,66,888 (-27%)	1.12 (+18%)	11.82 (-39%)
RRC → FPS: Rice (45,000 Qtls)			
Baseline	16,44,524	1.63	22.40
Fully Optimised (Capacity Constrained +15%)	11,65,293 (-29%)	1.63	15.89 (-29%)
FCI → RRC: Wheat (8000 Qtls.)			
Baseline	1,57,941	0.86	22.92
Fully Optimised (Capacity Constrained +15%)	1,60,584 (+2%)	0.83 (-3%)	24.09 (+5%)
RRC → FPS: Wheat (8000 Qtls.)			
Baseline	2,89,750	1.63	22.22
Fully Optimised (Capacity Constrained +15%)	1,92,198 (-34%)	1.63	14.74 (-34%)

Table 29: Key output KPI's for scenario fully optimised with capacity constraint +15%

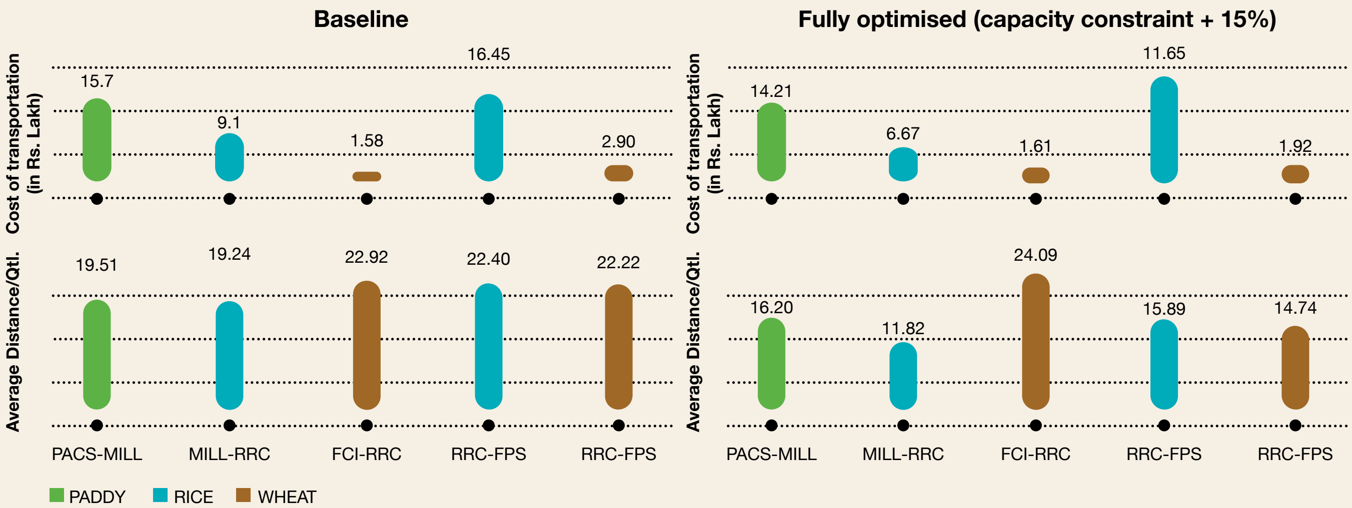


Figure 70: Total Distance and cost of transportation for all legs in fully optimised with capacity constraints +15% scenario

12.4. CHANGES FROM THE BASELINE

In the optimal configuration of this scenario the tagging of 53 out of 80 PACS changes and the tagging of 305 out of 565 FPS changes. This results in a cost decrease of 9% in leg 1, 27% in leg 2 and 30% in leg 3 but a 2% increase in costs in the FCI to RRC leg. This is because with the optimisation under the given constraints the average cost/Qtl has decreased for all other legs except the FCI to RRC leg.

12.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

12.4.1.1. TAGGING AND VOLUME

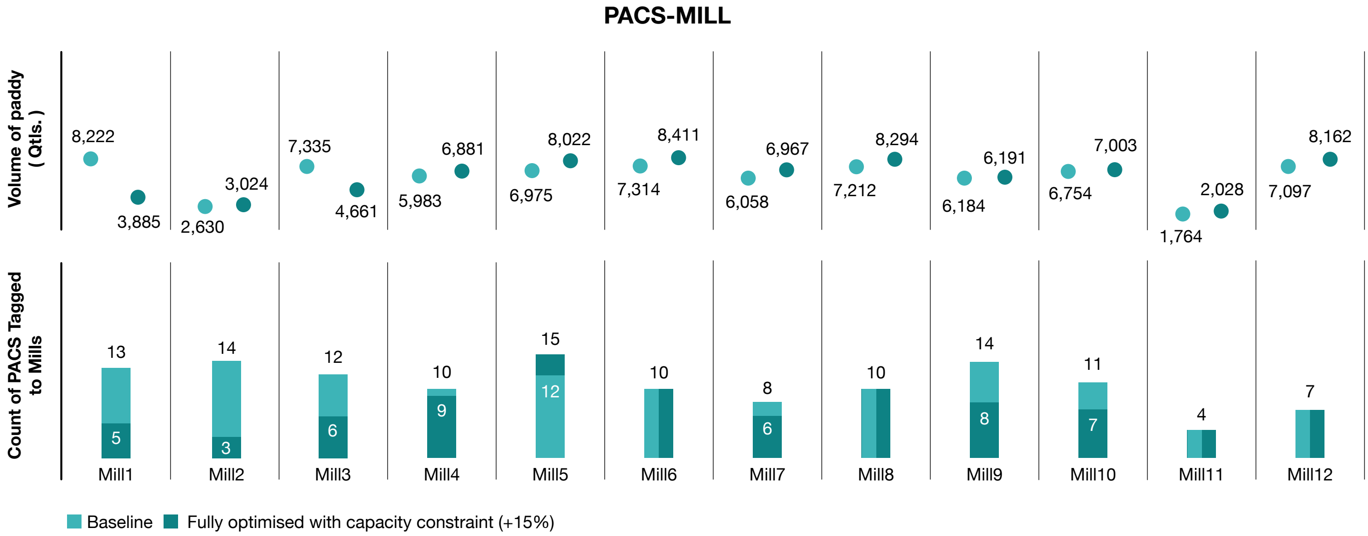


Figure 71: Tagging and volume of paddy from PACS to mills in the fully optimised with capacity constraint +15% scenario

- Tagging of PACS to mills has been changed. The number of nodes traversed had reduced for 125 to 75.
- The allocation to each mill has been increased by 15%. Figure 71 describes the changes in tagging and volume of paddy allocated to each mill in comparison to the baseline.

12.4.1.2. DISTANCE AND COSTS

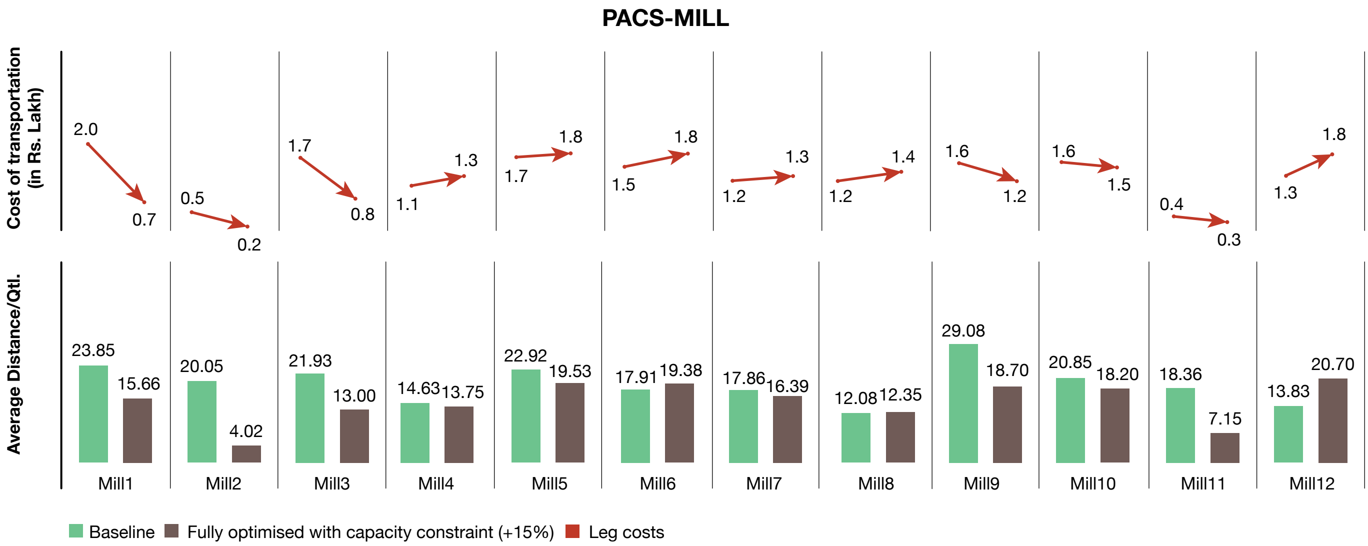


Figure 72: Cost of transportation and distance travelled from PACS to mills in the fully optimised with capacity constraint +15% scenario

Costs and distance travelled are aligned to the changes in the allocation and tagging of PACS to Mill. Distance between PACS and mills have significantly reduced for all mills except for Mill 5 (Kamlesh Rice Mill) and Mill 12 (Tareni Agro Foods), where the tagging and average distance/Qtl. has increased.

12.4.2. OBSERVATIONS FOR LEG 2: MILL TO RRC AND FCI TO RRC

12.4.2.1. TAGGING AND VOLUME

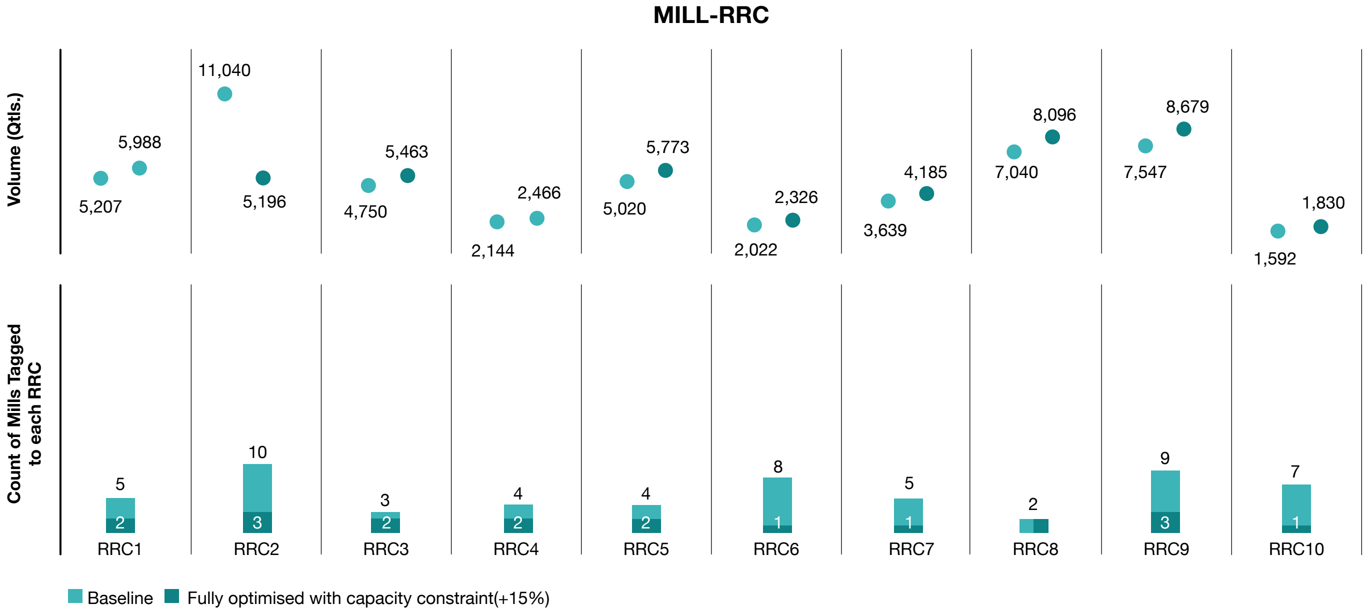


Figure 73: Tagging and allocation of rice from mills to RRCs in the fully optimised with capacity constraints +15% scenario

- Tagging of Mill to RRC as well as the allocation of rice to RRCs has been changed in this scenario. Figure 73 describes the changes in tagging and allocation of each RRC.
- Except for RRC 2, the allocation for all RRC,s have been increased by about 15% of its existing allocation.
- The number of nodes traversed have reduced from 57 to 19.
- Figure 74, describes the changes in allocation of wheat between FCI and RRC in comparison to baseline.
- Tagging for FCI-RRC remains 1 to 1 as in the baseline, but allocation of wheat has been increased for all RRCs except RRC 2.

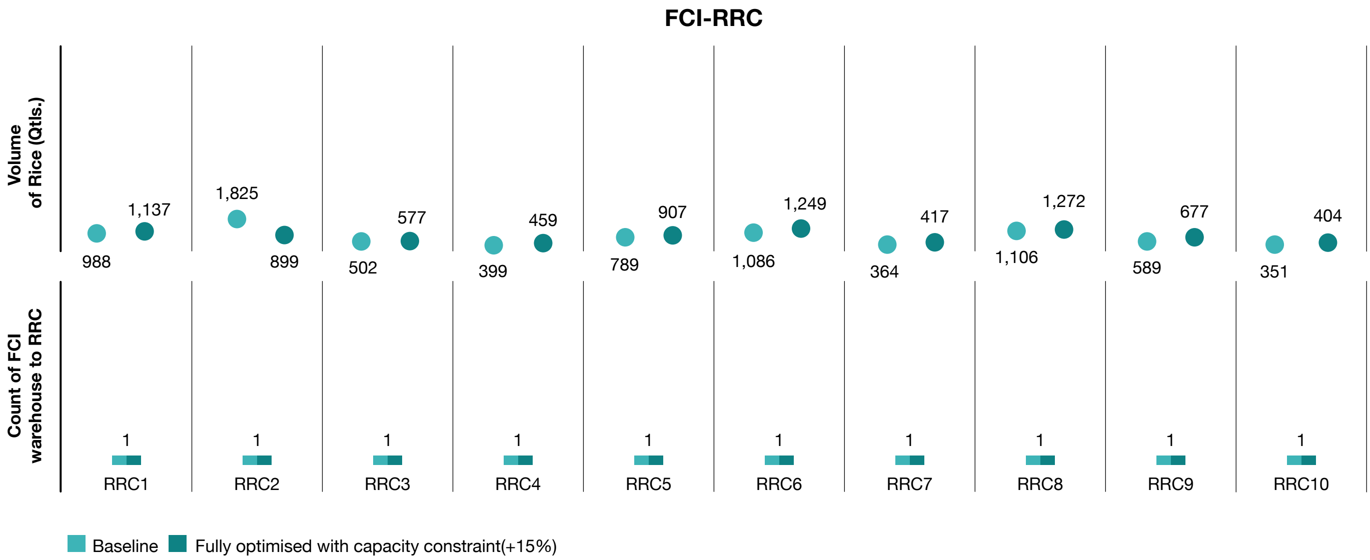


Figure 74: Tagging and allocation of wheat from FCI to RRCs in the fully optimised with capacity constraints +15% scenario

12.4.2.2. DISTANCE AND COSTS

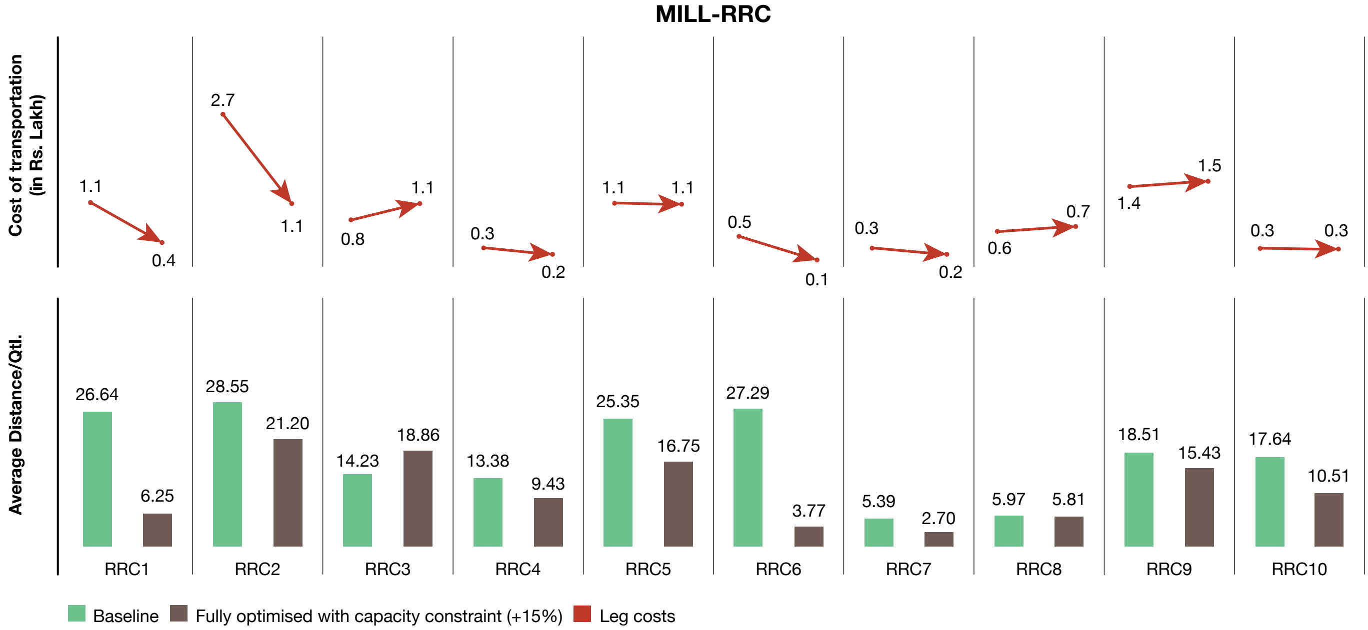


Figure 75: Cost of transportation and distance from mills to RRC in the fully optimised with capacity constraint +15% scenario

- The distance and cost of transportation has reduced for most RRCs. For RRC 9 even though average distance/Qtl. has reduced, the cost of transportation has increased because the total volume allocated to the RRC has increased. Similarly for RRC 2, the cost of transportation has decreased significantly, since the volume allocated to the RRC as well as the average distance/Qtl. has dropped.
- The distance between mills and RRCs have significantly reduced resulting in cost reduction of 27%.

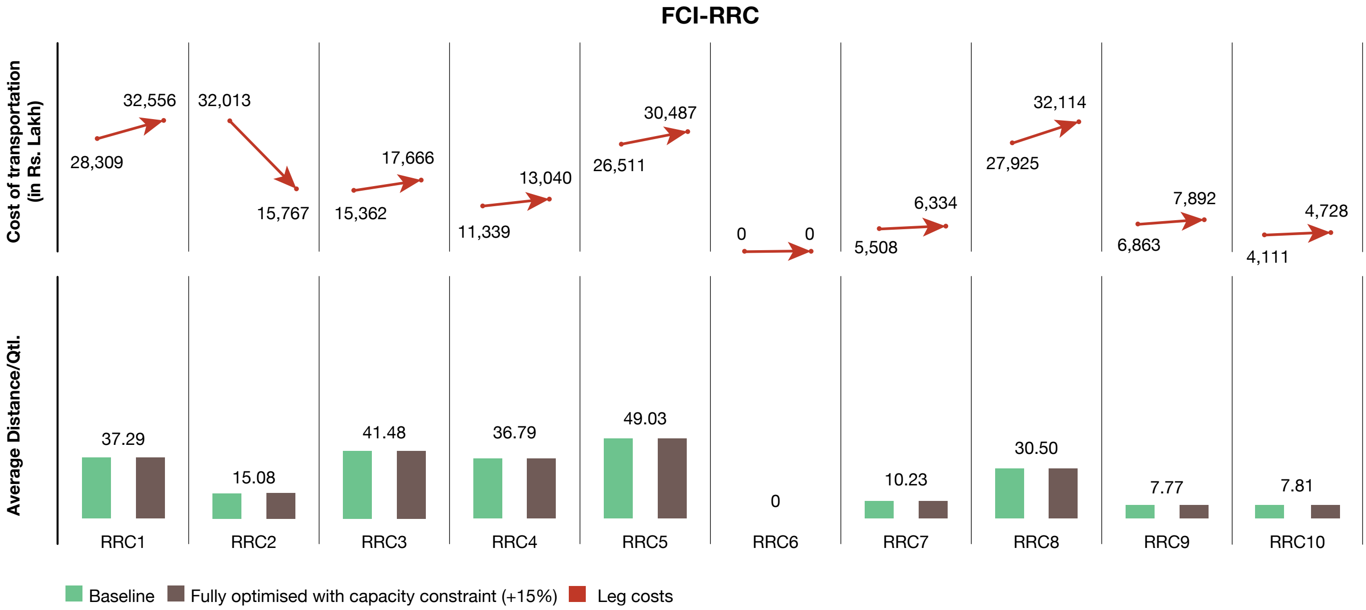


Figure 76: Cost of transportation and distance from FCI to RRC in the fully optimised with capacity constraint +15% scenario

The distance travelled from FCI to RRC, shows no change, but due to the changes in the volume of wheat from FCI to each RRC, the costs have changed. Overall, the cost has increased by 2%.

12.4.3. OBSERVATIONS FOR LEG 3: RRC TO FPS

12.4.3.1. TAGGING AND VOLUME

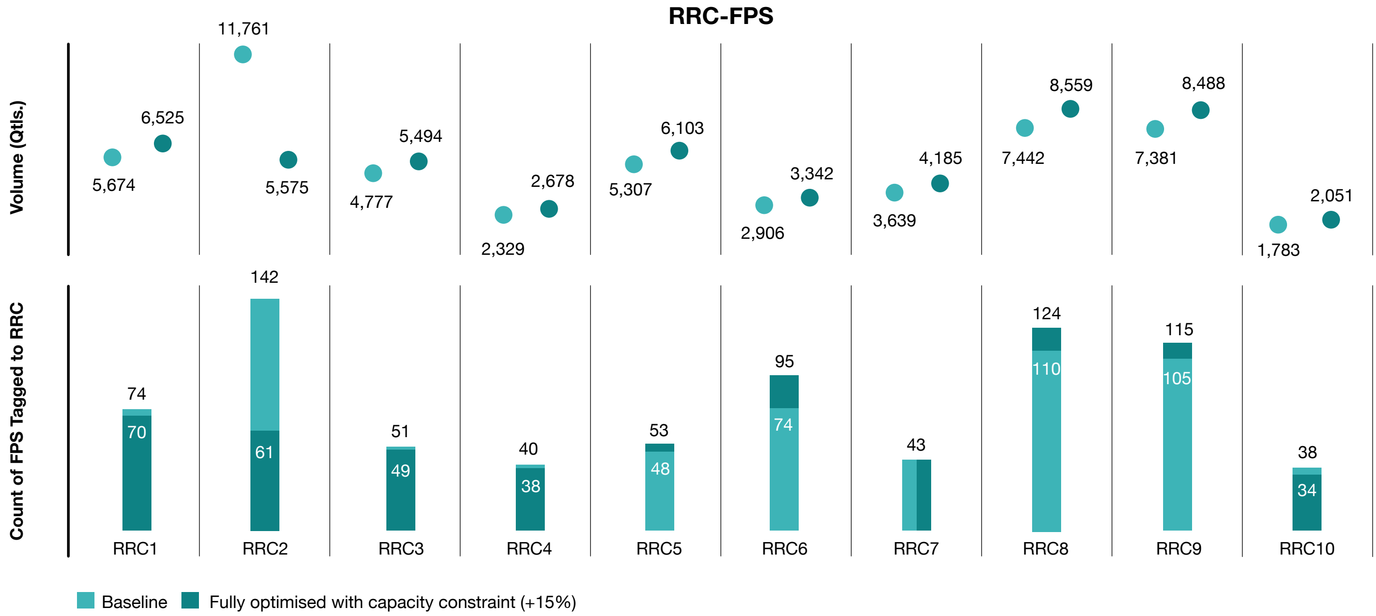


Figure 77: Tagging and volume from RRCs to FPS in fully optimised with capacity constarint +15% scenario

Tagging and volume of rice and wheat from RRC to FPS can be observed in figure 77. For RRC 2 (Baladiabandha) tagging and allocation of foodgrains has been significantly reduced, through reallocating the tagged FPS and their allocation to the other RRCs.

12.4.3.2. DISTANCE AND COSTS

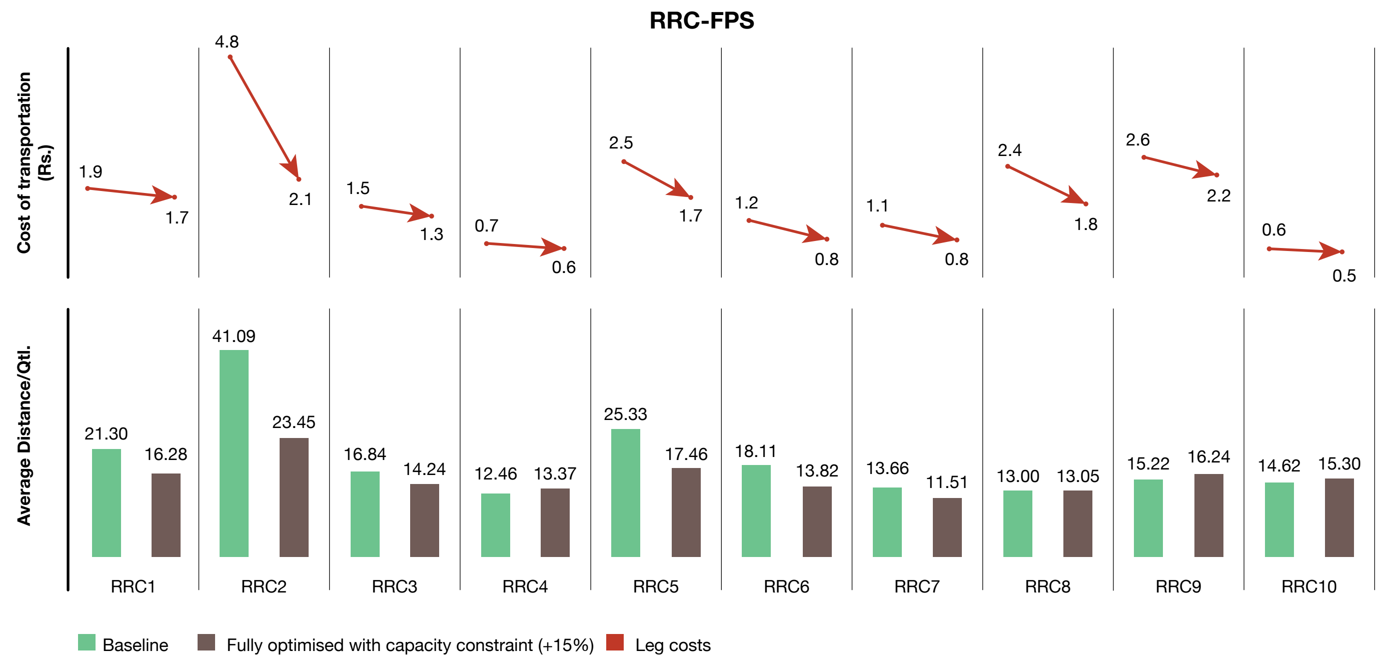


Figure 78: Cost of transportation and distance from RRC to FPS (Rice and Wheat) in the fully optimised with capacity constraint +15% scenario

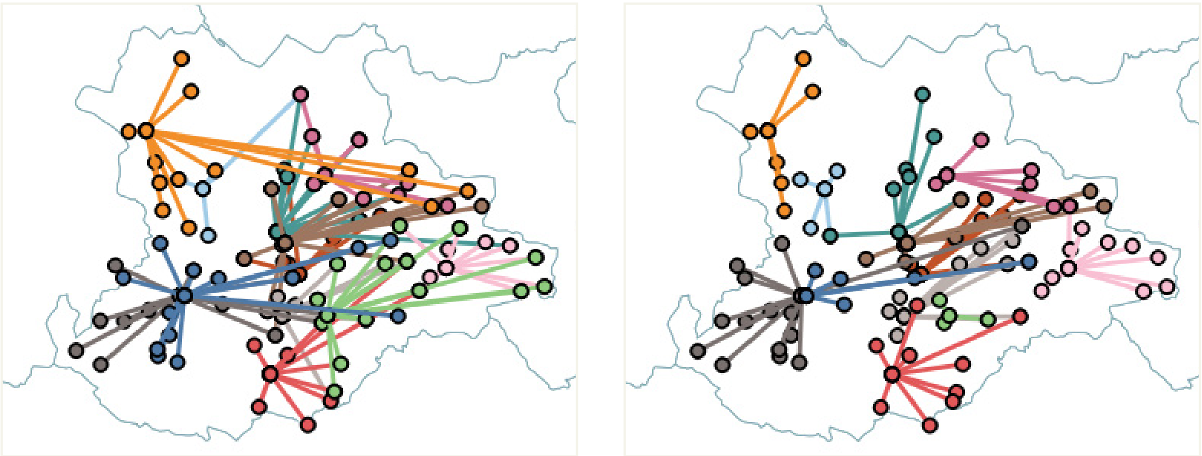
Distance travelled between RRC and FPS have decreased for 50% of RRCs, but the cost of transportation has decreased for all RRCs. This is assuming Rs. 1.63 per Qtl. per Km. costs as derived based on the current average cost of transportation.

12.4.4. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE FULLY OPTIMISED WITH CAPACITY CONSTRAINED +15% SCENARIO

Figure 79-81 describe the geo tagging of nodes for each leg in this scenario. The tagging in all legs is very similar, but more optimised than the scenario fully optimised with capacity constrained. There is no change in tagging from FCI to RRC, hence geo-representation for that leg is not included.

PACS-MILL
Baseline

PACS-MILL
Fully optimised with capacity constraint +15%



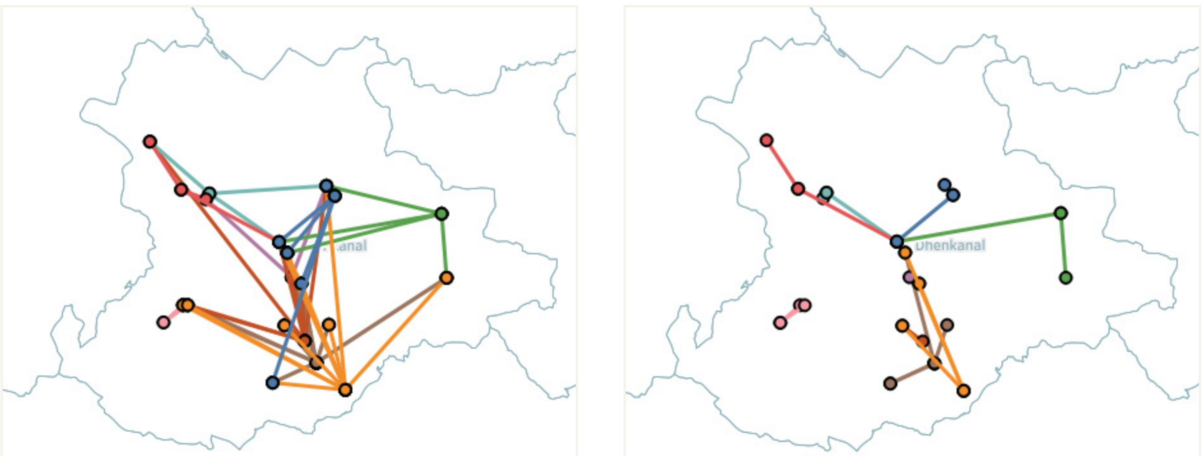
Destination

Mill 1 | Mill 2 | Mill 3 | Mill 4 | Mill 5 | Mill 6 | Mill 7 | Mill 8 | Mill 9 | Mill 10 | Mill 11 | Mill 12

Figure 79: Geo-representation of tagging from PACS to Mills in fully optimised with capacity constarints +15% scenario

MILL-RRC
Baseline

MILL-RRC
Fully optimised with capacity constraint +15%



Destination

RRC 1 | RRC 2 | RRC 3 | RRC 4 | RRC 5 | RRC 6 | RRC 7 | RRC 8 | RRC 9 | RRC 10

Figure 80: Geo-representation of tagging from Mills to RRC in the fully optimised with capacity constarint +15% scenario

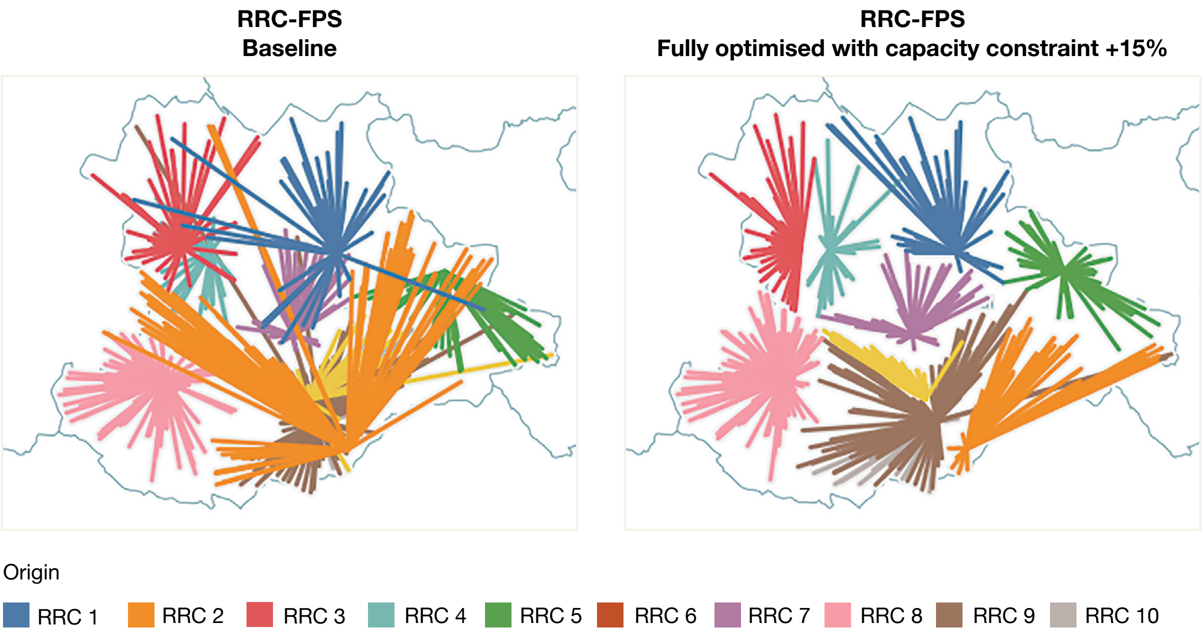


Figure 81: Geo-representation of tagging from RRC to FPS in the scenario fully optimised with capacity constarint +15%

12.5. CHANGES REQUIRED TO IMPLEMENT THE SCENARIO

POLICY CHANGES

- Classification of Supply Zones in the Food Security Rules and assigning of responsibilities.
- Revision in the methodology for contracting of transporters including contracting terms, transportation rate etc. to accommodate recommendation to move from per Qtl. rate to per Qtl. per Km. rate for the last leg i.e. RRC to FPS.

TECHNICAL CHANGE

- Changes to the SCMS and P-PAS databases on tagging of nodes: i.e. tagging of mills to RRCs and RRCs to FPS in SCMS and tagging of PACS to mills in the P-PAS system
- Changes to the SCMS and P-PAS Databases on allocation of nodes: i.e. allocation of mills in P-PAS and allocation of rice at each RRC from mills in SCMS.

OPERATIONAL CHANGE

- Contracting of new Transport agents (L1 and L2 transporters) or changes to existing contracts to accommodate changes in rates of transportation, allocation and tagging.
- Preparation of new allocation orders based on the changes in tagging of RRC to FPS.
- Changes in the planning/execution, delivery schedules and pick up of paddy, rice and wheat between the various nodes.

SCENARIO 10
FULLY OPTISMISED

13

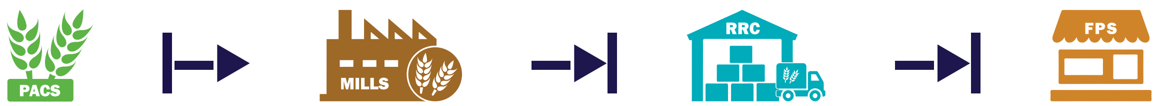
CHAPTER

SCENARIO 10.
FULLY OPTIMISED

13.1. ABOUT THE SCENARIO

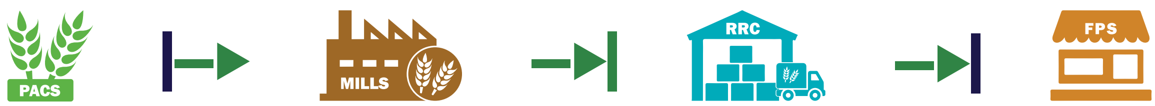
In this scenario, the optimisation model chooses to change the tagging and allocated volume in all the three legs i.e PACS to Mill, Mill to RRC, FCI to RRC and RRC to FPS, as long as all the procured paddy picked up from the PACS and the demand of rice, wheat is fulfilled at the FPSs. This scenario thus provides insight on the changes that could potentially be made in the network to maximise the cost savings, while ensuring that it is practical to implement. The change in throughput of the different locations i.e mills, RRCs as compared to the baseline provides information about what locations should be expanded or reduced to minimise the costs of transportation. Overall, the costs savings in this scenario is 29% or Rs.13,23,474, with cost savings of 13%, 50% and 32% in leg 1, 2 and 3 respectively.

SCENARIO: BASELINE



TTC: Rs. 45,71,640 | ADT: 84 Km./Qtl. | ATC: 1.21 Rs. per Km./Qtl

SCENARIO: FULLY OPTIMISED



TTC: Rs. 32,48,206 (-29%) | ADT: 54.9 Km./Qtl. | ATC: 1.37 Rs. per Km./Qtl.

● *Can be changed* ● *Remains the same* ● *Can be closed*

Table 30: Summary statistics for the fully optimised scenario

***TTC - Total Transport Costs | ADT - Average Distance Travelled | ATC - Average Transportation Costs*

13.2. KEY CONSTRIANTS

1. All paddy that is procured must be transported to one of the mills in the district.
2. All paddy that is procured from the PACS must be processed by the mills.
3. All mills have an efficiency of 68%: for every Kg. of paddy that flows into the mill it produces exactly 0.68 Kg. of rice.
4. All rice that is produced at the mills is transported to one of the 10 RRCs in Dhenkanal.
5. All demand for rice and wheat at every FPS must be satisfied.
6. All wheat demand flows into the district at the FCI (Dhenkanal).

13.3. KEY PERFORMANCE INDICATORS

	Total Transportation Costs (Rs. /month):	Average Transportation Costs (Rs. /Qtl. /Km.):	Average Distance Travelled (Km. /Qtl.):
PACS → Paddy (73,529 Qtls) → MILLS			
Baseline	15,69,794	1.09	19.51
Fully Optimised	13,58,835 (-13%)	1.26 (+16%)	14.57 (-25%)
MILLS → Rice (45,000 Qtls) → RRC			
Baseline	9,09,631	0.95	19.24
Fully Optimised	4,55,514 (-50%)	1.31 (+37%)	6.96 (-64%)
RRC → Rice (45,000 Qtls) → FPS			
Baseline	16,44,524	1.63	22.40
Fully Optimised	11,09,461 (-33%)	1.63	15.13 (-32%)
FCI → Wheat (8000 Qtls.) → RRC			
Baseline	1,57,941	0.86	22.92
Fully Optimised	1,17,514 (-26%)	0.81 (-7%)	18.22 (-21%)
RRC → Wheat (8000 Qtls.) → FPS			
Baseline	2,89,750	1.63	22.22
Fully Optimised	2,06,881 (-29%)	1.63	15.87 (-29%)

Table 31: Key output KPI's for the fully optimised scenario

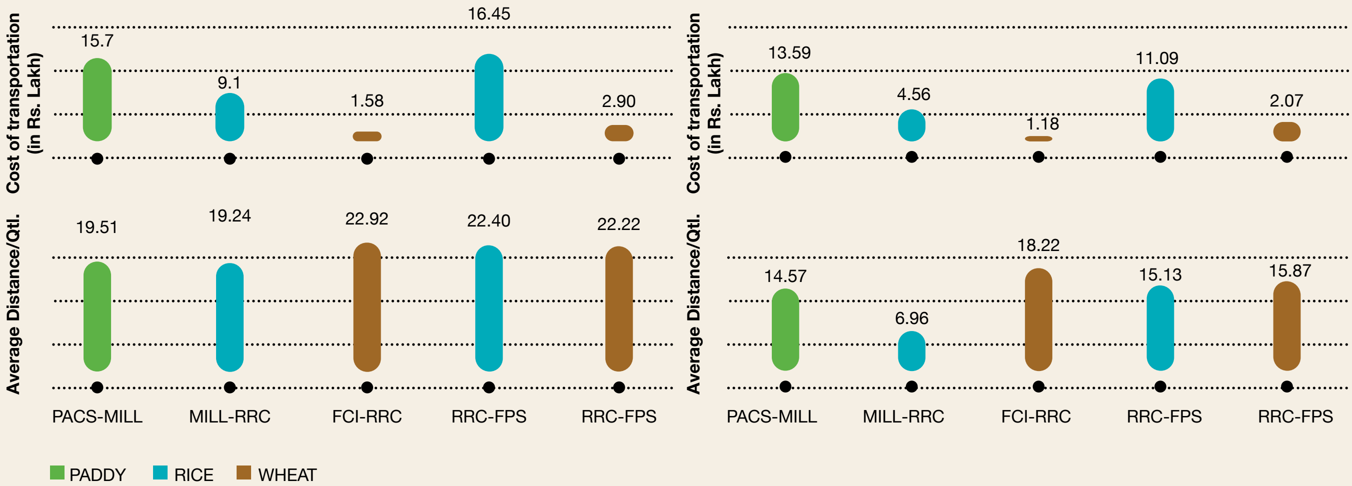


Figure 82: Total cost of transportation and average distance/Qtl. in all legs for the fully optimised scenario

13.4. CHANGES FROM THE BASELINE

In this scenario, the tagging and throughput of all nodes of the supply chain have been changes, keeping the total procurement at PACS and distribution at FPS same as the baseline. Overall, the cost of transportation and average distance/Qtl. has reduced in all legs of the supply chain.

13.4.1. OBSERVATIONS FOR LEG 1: PACS TO MILL

13.4.1.1. TAGGING AND VOLUME

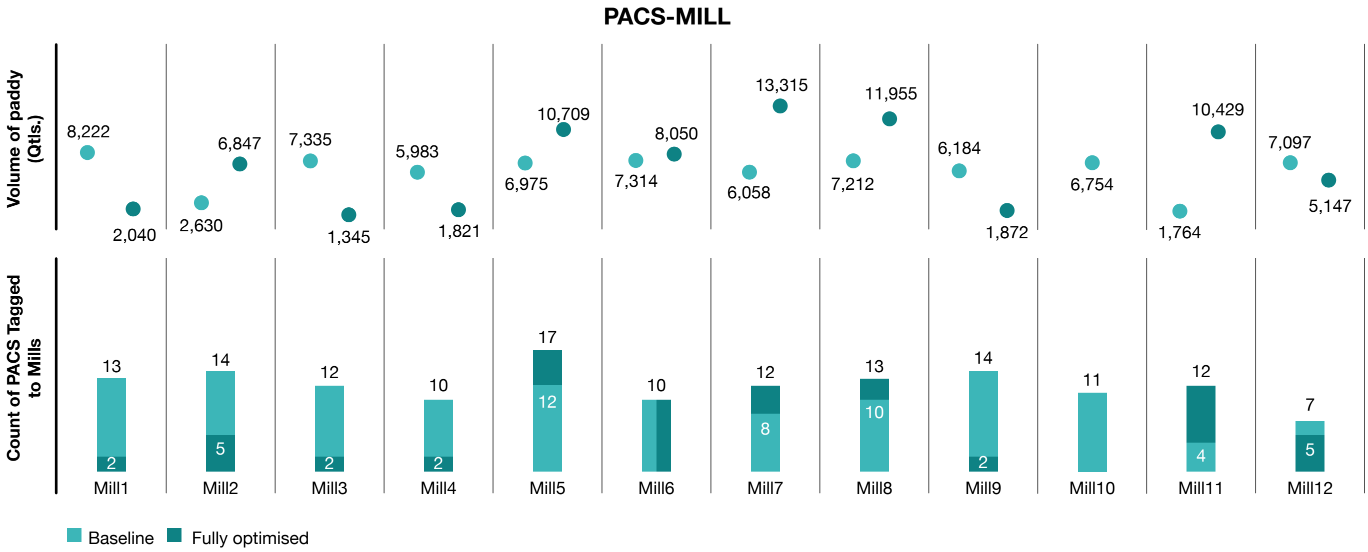


Figure 83: Tagging and volume of paddy from PACS to mills in the fully optimised scenario

- The number of PACS tagged to each mill has been changed, without any change in total quantity of paddy picked from each PACS or the total number of PACS.
- The number of nodes traversed in this leg have reduced from 125 to 82.
- The quantity of paddy processed by each mill has changed, without any change in the total quantity of paddy processed by all mills. Figure 83, describes the change in volume processed by each mill as compared to the baseline.
- These changes have led to an overall reduction of 13% in total transportation costs.
- Mill 10 (Panchasakha Rice Mill) has not been tagged to any PACS in the fully optimised scenario.

13.4.1.2. DISTANCE AND COSTS

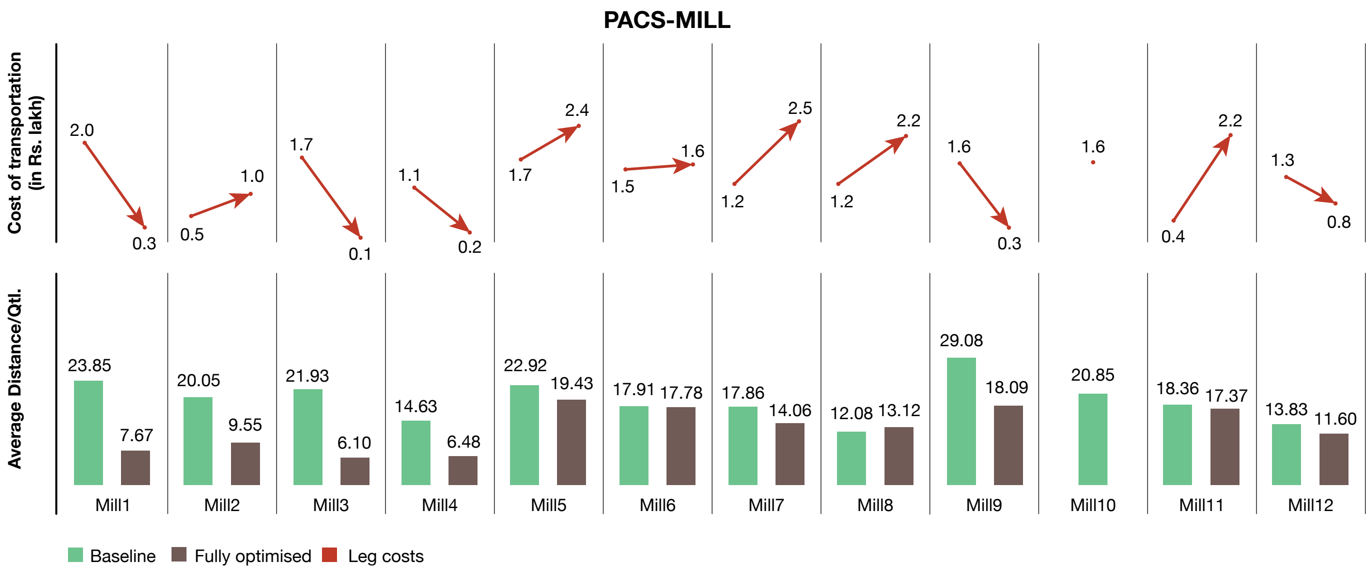


Figure 84: Cost of transportation and average distance/Qtl for PACS to mills in the fully optimised scenario

The average distance/Qtl. has reduced by 25% and cost of transportation by 13% in the PACS to Mill leg for the fully optimised scenario. For 50% of the mills i.e Mill 2,5,6,7,8,11, the cost of transportation has gone up, since the volume of paddy allocated to these mills has gone up.

13.4.2. OBSERVATIONS FOR LEG 2: MILL TO RRC AND FCI TO RRC

13.4.2.1. TAGGING AND VOLUME

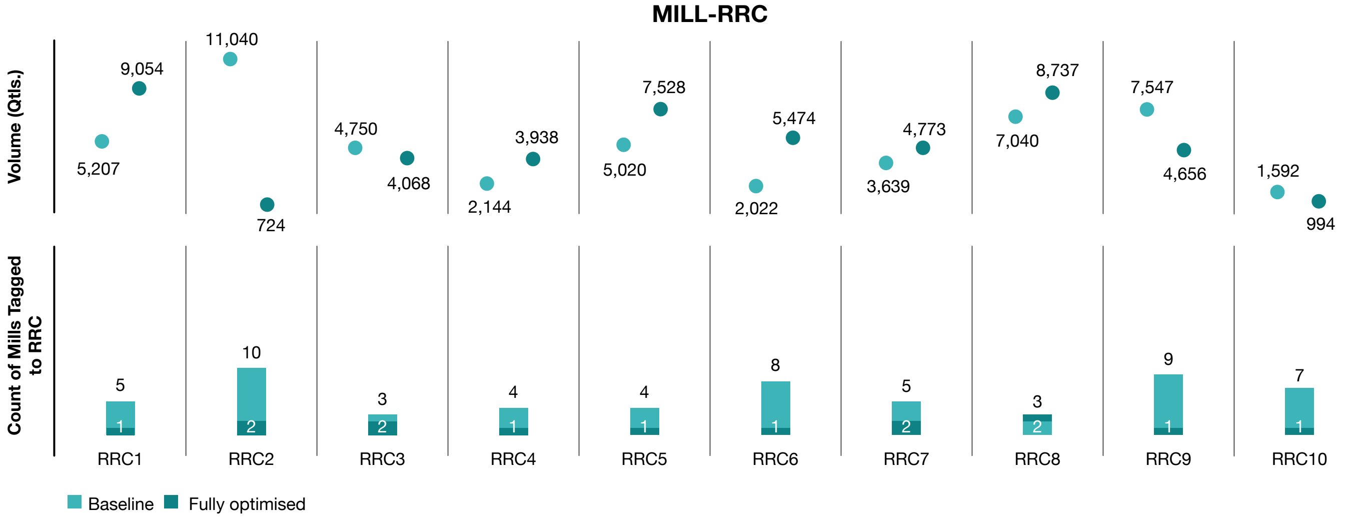


Figure 85: Tagging and volume of rice from mills to RRC in the fully optimised scenario

- The number of mills tagged to each RRC has been optimised, with the number of nodes traversed reduced from 57 to 15.
- The allocation of RRC 2,3,9 and 10 has been decreased, while for all other RRC's the total allocation has increased.
- FCI Dhenkanal (RRC6) stores wheat which is then transported to other RRCs. In all other scenarios' FCI Dhenkanal is tagged to all the RRCs, but in this scenario RRC 9 and 10 no longer receive wheat from FCI (Figure 86).
- Total allocation to RRC 6 has been trippled, while for RRC2 it has been reduced to 5% of its allocation in baseline (Figure 86).
- This overall quantity of wheat procured from FCI as well as wheat delivered to individual FPSs for distribution to beneficiaries has not been changed.

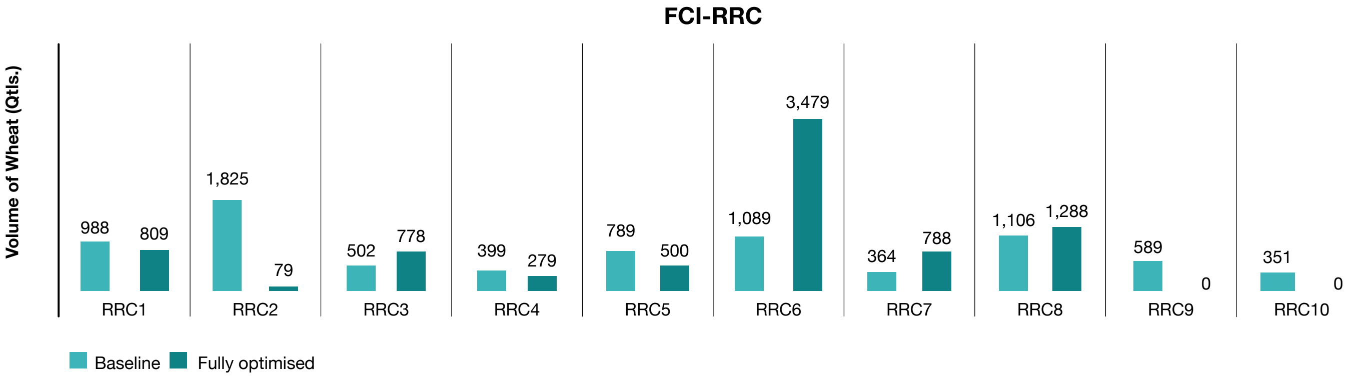


Figure 86: Volume of wheat from FCI to RRC

13.4.3. DISTANCE AND COSTS

- Overall, as described in Figure 87, 88 the total cost and average distance/Qtl. has reduced considerably in leg 2 i.e. Mill to RRC and RRC to FCI in the fully optimised scenario.
- For RRC 6 the distance travelled and cost of transportation is zero since FCI Dhenkanal and RRC 6 is same. Since RRC 9 and 10 are not allocated any wheat, the costs in the fully optimised scenario for these RRCs is zero.

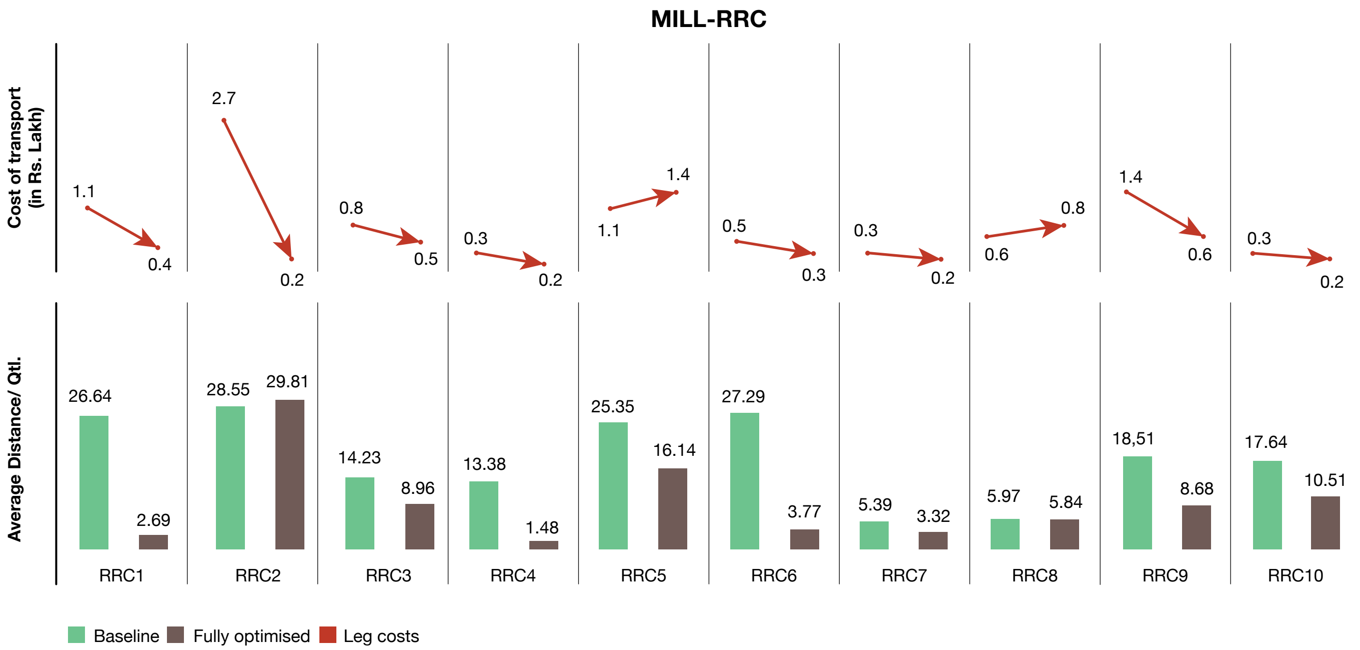


Figure 87: Average distance per Qtl. and cost of transportation from mills to RRC for the fully optimised scenario

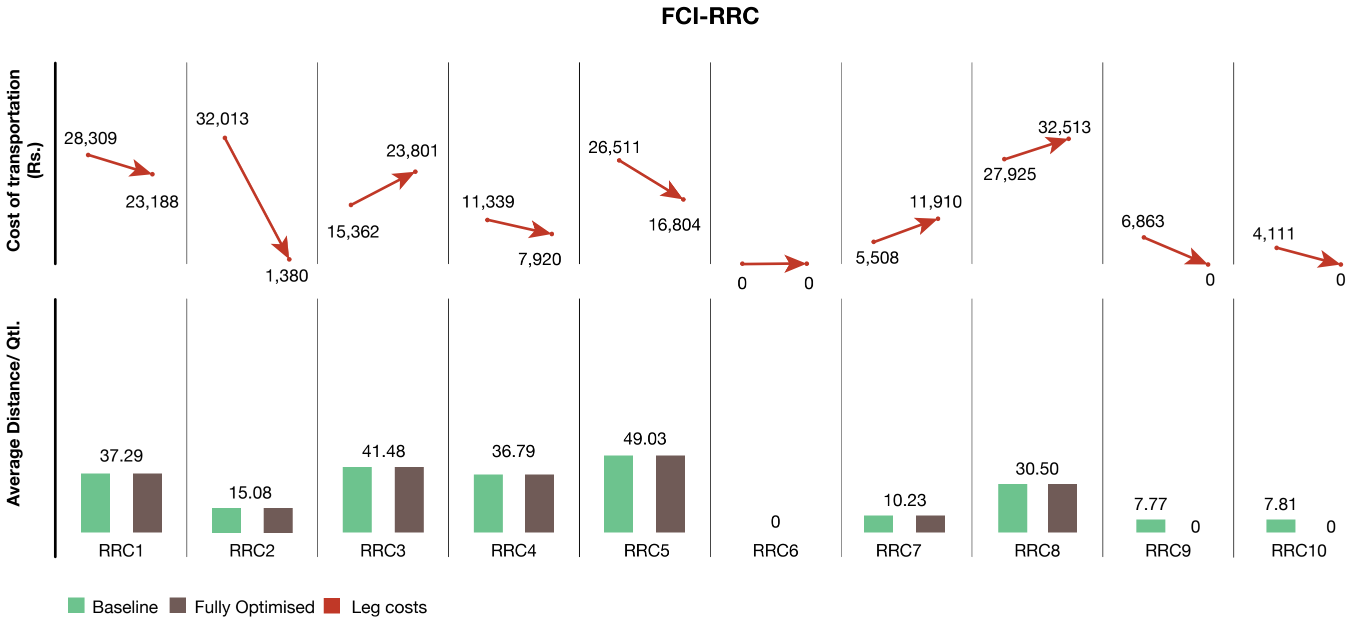


Figure 88: Avearge distance per Qtl. and cost of transportation from FCI to RRC for the fully optimised scenario

OBSERVATIONS FOR LEG 3: RRC TO FPS

13.4.3.1. TAGGING AND VOLUME

- There is change in the number of FPS tagged to each RRC without any change to the total quantity of rice and wheat delivered to each FPS
- In line with the increased allocation of both wheat and rice to RRC6, the number of FPS tagged to RRC 6 have increased three times. (Figure 89).
- Since RRC 9 and 10 are not tagged to FCI Dhenkanal, the cost of transporatation and average distance for these RRC's is 0.

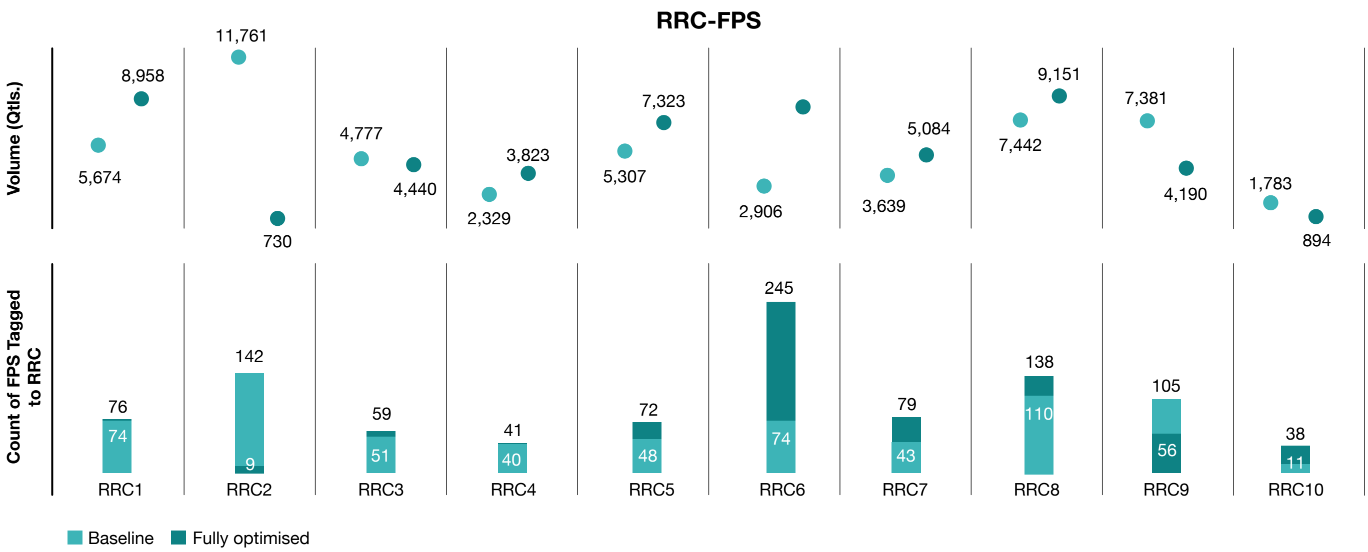


Figure 89: Tagging and volume of rice and wheat from RRC to FPS

13.4.3.2. DISTANCE AND COSTS

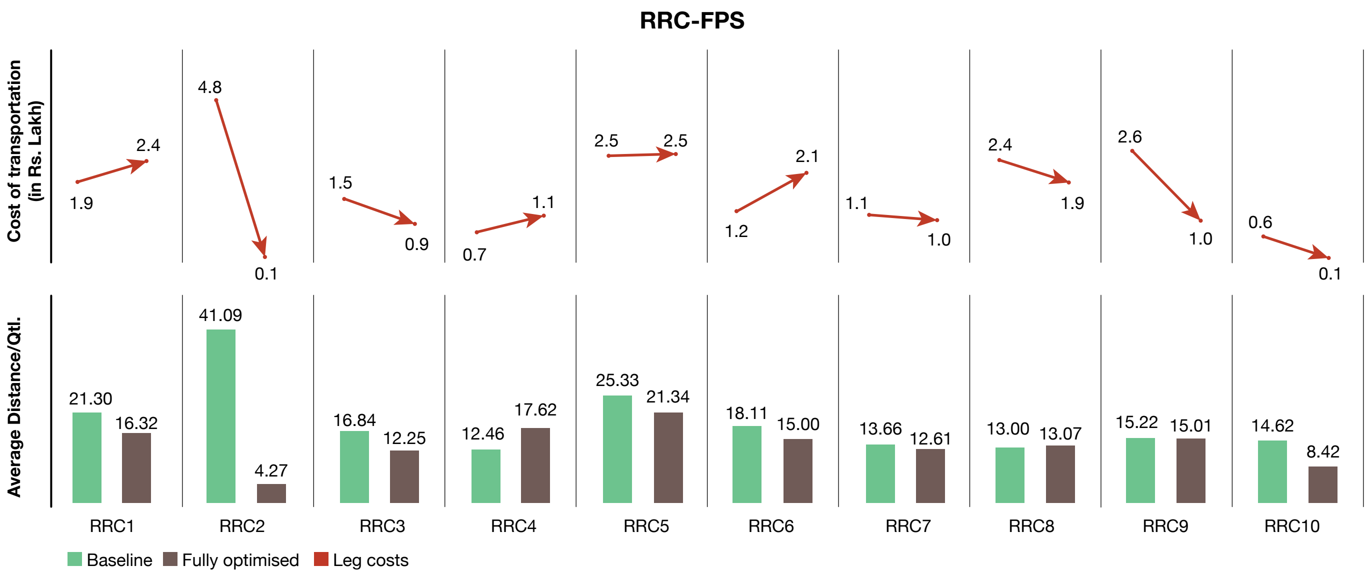


Figure 90: Cost of transportation and average distance per Qtl. of RRC to FPS in the fully optimised scenario

- For RRC 1, even though the average distance per Qtl. has reduced, the tagging and volume of rice from RRC to FPS has increased, hence the costs have increased.
- As tagging and allocation to RRC 2 (Baladiabandha) has been reduced significantly, the average distance/ Qtl. and cost of transportation has also reduced significantly. Overall the reduction in total costs in this leg is 32%. (Figure 90).

13.4.4. GEOSPATIAL REPRESENTATION OF THE SUPPLY CHAIN NETWORK IN THE FULLY OPTIMISED

- Overall figures 91-94 describe the tagging of nodes in all legs i.e. PACS to Mill, Mill to RRC, FCI to RRC and RRC to FPS. It can be observed that the tagging is optimised for all the legs leading to reduction in distance and cost of transportation.
- Tagging from mills to RRC has been further optimised from scenario 8 and 9. As can be seen, number of mills tagged to RRCs have reduced considerably, with maximum reduction in tagging for RRC2 (Baladiabandha). (Figure 92)
- Figure 93, shows the tagging from FCI to RRC. As can be seen, RRC9 and 10 are not tagged to FCI in the fully optimised scenario.
- Figure 94, represents the tagging between RRC to FPS for rice. As can be seen, the tagging has been optimised by supply zone thereby reducing the overall distance and costs in each leg 13.4.

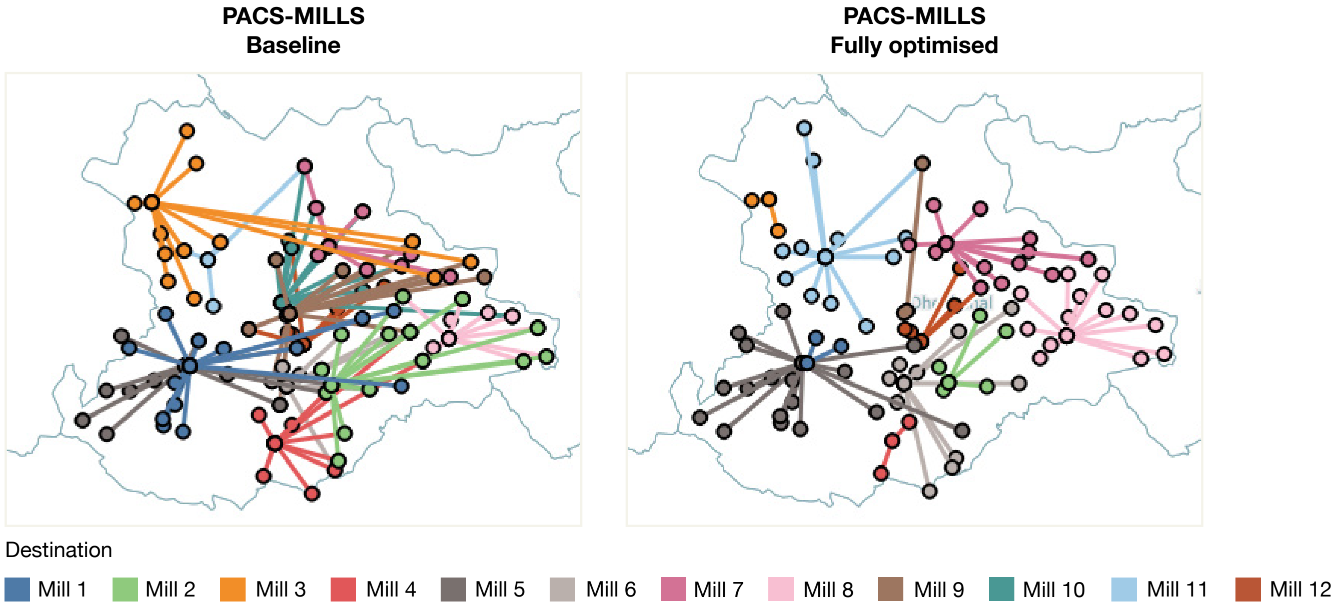


Figure 91: Geo-representation of tagging from PACS to mills in the fully optimised scenario

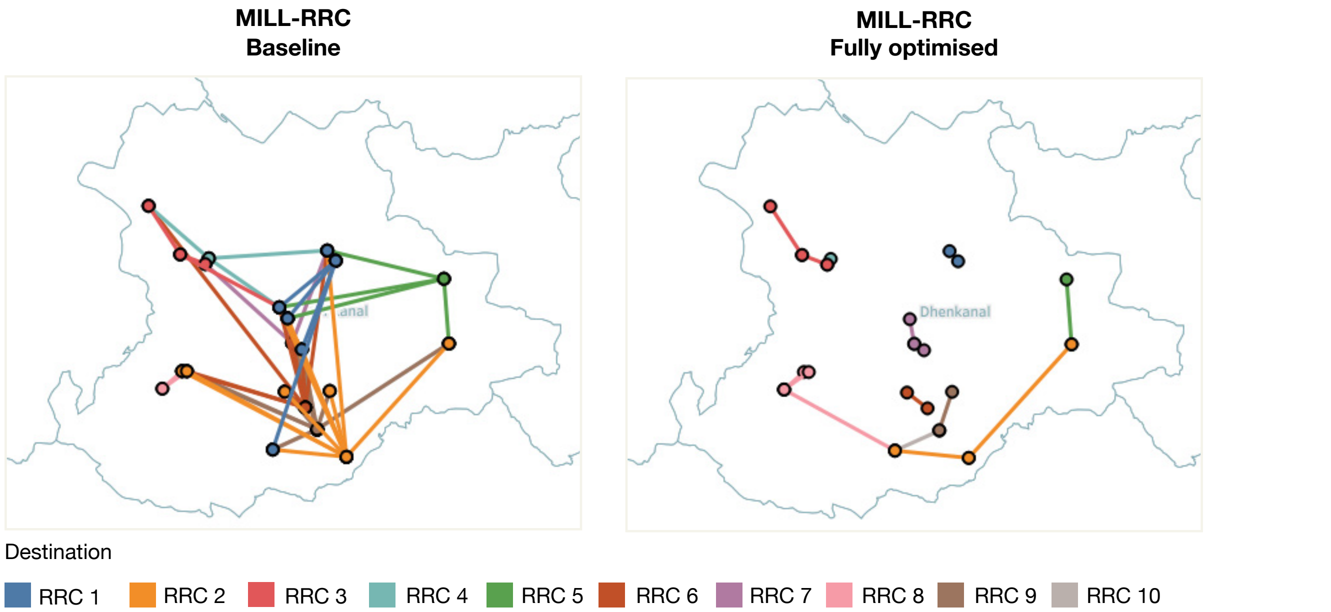


Figure 92 : Geo-representation of tagging from mills to RRC in the fully optimised scenario

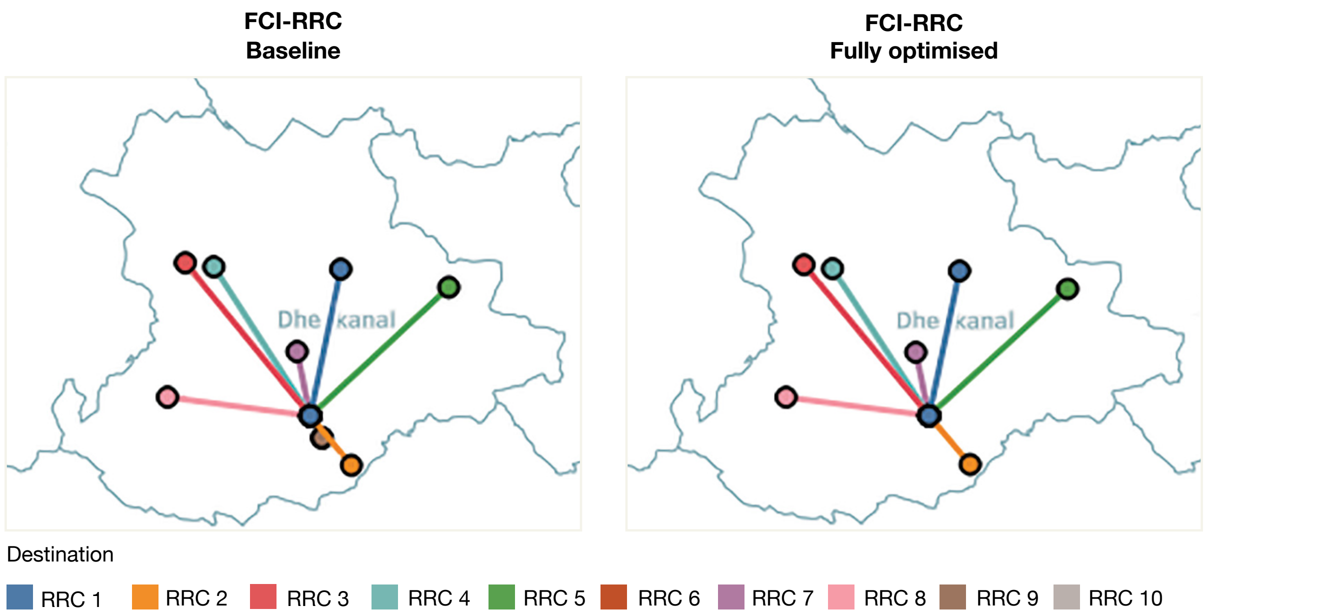


Figure 93: Geo-representation of tagging from FCI to RRC in the fully optimised scenario

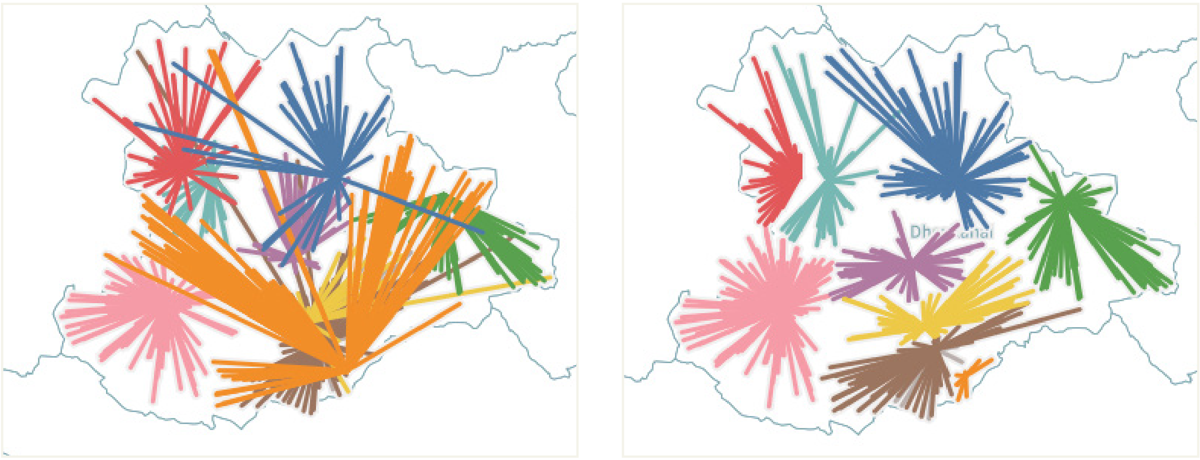


Figure 94: Geo-representation of tagging from RRC to FPS (rice only) in the fully optimised scenario

13.5. CHANGES REQUIRED TO IMPLEMENT THE SCENARIO

POLICY CHANGE

- Classification of Supply Zones in the Food Security Rules and assigning of responsibilities.
- Revision in the methodology for contracting of transporters including contracting terms, transportation rate etc. to accommodate recommendation to move from per Qtl. rate to per Qtl. per Km. rate for the last leg i.e. RRC to FPS.

TECHNICAL CHANGE

- Changes to the SCMS and P-PAS databases on tagging of nodes: i.e. tagging of mills to RRCs and RRCs to FPS in SCMS and tagging of PACS to mills in the P-PAS system
- Changes to the SCMS and P-PAS Databases on allocation of nodes: i.e. allocation of mills in P-PAS and allocation of rice at each RRC from mills in SCMS.

OPERATIONAL CHANGE

- Contracting of new Transport agents (L1 and L2 transporters) or changes to existing contracts to accommodate changes in rates of transportation, allocation and tagging.
- Preparation of new allocation orders based on the changes in tagging of RRC to FPS.
- Changes in the planning/execution, delivery schedules and pick up of paddy, rice and wheat between the various nodes.

ANNEXURES

ANNEXURE 1: LIST OF FIGURES

ANNEXURE 2: LIST OF TABLES

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