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Assessing the Impact of APCNF [Andhra Pradesh Community Managed Natural Farming] A Comprehensive Approach Using Crop Cutting Experiments

Institute for Development Studies Andhra Pradesh

Madhurawada , Visakhapatnam
Call: 9949219613

Email: directoridsap@gmail.com
Website: www.idsap.in

Assessing the Impact of APCNF

[Andhra Pradesh Community Managed Natural Farming]

A Comprehensive Approach using Crop Cutting Experiment

Second Interim [Rabi] Report 2023-24

Lead Researchers

Prof S. Galab

Dr G. Bhaskara Rao

Project Team

Prof C. Samba Murty

Dr D. Sree Rama Raju

Dr P. Prudhvikar Reddy

Prof C. Ravi

Prof J. Ramu Naidu

Dr S. Surapa Raju

Dr K. Ananda Rao

IDSAP

Madhurawada, Visakhapatnam 530041; www.idsap.in

☎ +91 9949 219 613; ☎ +91 7093 219 613

✉directoridsap@gmail.com; ✉director@idsap.in

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Project Team

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Acronyms

AP	**:**	**Andhra Pradesh**
APCNF	:	Andhra Pradesh Community Managed Natural Farming
ATM	:	Any-Time Money cropping model, which has regular cash flow
AY	:	Agriculture year
BC	:	Backward Class
CCEs	:	Crop Cutting Experiments
CI		Capital inputs
CNF	:	Community Managed Natural Farming
CRPs	:	Community Resource Persons
CSs	:	Case Studies
DES	:	Directorate of Economics and Statistics
DPMs	:	District Project Managers
FGDs	:	Focus Group Discussions
FLF		Family labor female
FLM		Family labor male
FLP		Family labor productivity
FPCs	:	Farmers' Producer Companies
FYM	:	Farm Yard Manure
GCA	:	Gross Cropped Area
GDP	:	Gross Domestic Production
GHG	:	Greenhouse gases
GoI	:	Government of India
GPs	:	Gram Panchayats
GR	:	Green Revolution
HAT	:	High Altitude Tribal Areas
HDI	:	Human Development Index
HLP	:	Hired labour productivity
HI	:	Herfindahl Index
IASRI	:	Indian Agricultural Statistical Research Institute
ICRPs	:	Internal Community Resource Persons
IDSAP	:	Institute for Development Studies Andhra Pradesh
MA	:	Mandal Anchor
MF	:	Master Farmer

MFIs	:	Microfinance Institutions
NGOs	:	Non-Governmental Organizations
NSA	:	Net Sown Area
NSO	:	National Statistical Office
NSSO	:	National Sample Survey Organization
OC	:	Open Categories
PMDS	:	Pre-Monsoon Dry Sowing
PNPIs	:	Plant Nutrient and Plant protection Inputs
PRDS	:	Pre-Rabi Dry Sowing
PRR	:	Price Risk Ratio
RySS	:	Rythu Sadhikara Samstha
SC	:	Scheduled Caste
SHGs	:	Self-Help Groups
SIs	:	Strategic Interviews
ST	:	Scheduled Tribe
TTD	:	Tirumala Tirupati Devasthanam
VOs	:	Village Organizations
YRR	:	Yield Risk Ratio
ZBNF	:	Zero Budget Natural Farming

Executive Summary

0.1. Introduction

1. The specific objectives of the present study are:
   - To assess the impact of CNF on the farming conditions, such as cost of cultivation, crop-yields, crop output prices, value of crop output at the state level during Rabi 2023-24.
   - To evaluate the impact of CNF on farming conditions in the different agroclimatic zones and across farmer categories.
   - To assess the contribution of family female labour to agricultural production and productivity for different crops.
   - To examine the contribution of coordinated family labour to family labour productivity, hired labour productivity and crop yields.
   - To appraise the impact of CNF on input use in farming and related changes.
   - To review the issues and challenges in implementation of the program, and
   - To provide insights to ease the implementation of the program.
2. A total of 1,348 CNF and 842 non-CNF samples are selected for the study and surveyed during both Kharif and Rabi seasons of 2023-24.
3. The Crop Cutting Experiments (CCEs) were conducted scientifically to get an independent estimate of crop yields under CNF and non-APCNF.[1] In total 1,498 CCEs were conducted for all crops covered. These include 1,235 for cross-section farmers and 263 for panel farmers. The cross-section CCEs include 808 CCEs for CNF crops and 427 for non-CNF crops.
4. The present report covers seven crops, viz. (1) Paddy, (2) Groundnut, (3) Bengal gram, (4) Maize, (5) Black gram, (6) Green gram and (7) Ragi.

0.2. Impact of CNF on the farming conditions

That chapter deals with changes in cost of cultivation, crop yields, output prices, and gross and net value of crop output due to CNF during the Rabi season of 2023-24. The major difference between CNF and non-CNF is the use of the plant nutrient and protection inputs

[1] Needless to say, these CCEs add immense value to the study as these are conducted, independently by IDSAP, a third party, using the scientific method, which is being used by almost all official agencies.

(PNPIs)[2]. As a results, both the methods lead to different outcomes.

5. The difference in the expenditure on PNPIs is statistically significant in six out of seven crops covered. In all these six crops, the CNF farmers obtained savings. On average, the CNF farmers saved ₹8,377 per hectare in PNPIs compared to that of non-CNF farmers. The savings are equal to 58 per cent of non-CNF farmers' expenditure on PNPIs (Table 1.1).
6. The paid-out cost is significantly less under CNF in five out of seven crops. The difference is not statistically significant in other two crops. On average, the CNF farmers saved ₹7,534 per hectare in their paid-out costs. It is equal to 17 percent of the paid-out costs of non-CNF farmers (Table 2.2).
7. When the share of PNPIs declines in CNF, the share of other major components such as hired human labour and machine labour increase. It is obvious and observed in all crop. But the actual (absolute) expenditure did not increase on these items. The expenditure on major items, especially on hired human labour and machine labour are more or less the same under CNF and non-CNF. There are marginal variations (Table 2.4).
8. Out of seven crops considered in this report, the differences in yields of CNF and non-CNF are not statically different in five crops. In remain two crops, the CNF yields are higher in Groundnut and lower than that of non-CNF in Black gram (Table 2.5).
9. Though CNF proved to be profitable, even without any special prices, the farmers want higher prices for their CNF output. The farmers are of the opinion that their CNF output is quality output without chemicals, and, hence higher prices can be expected for the same.
10. The differences in the prices of CNF and non-CNF output are statistically significant in only two crops, viz., Paddy and Black gram. (Table 2.6).
11. On average, the CNF farmers obtained ₹4,607 per hectare or 4.8 percent higher gross value of output. CNF farmers got more gross values than non-CNF farmers in four out of seven crops (Table 2.7).
12. On an average the CNF farmers obtained ₹12,142 per hectare or 24.1 percent of higher net value of crop output compared to that of non-CNF farmers (Table 2.8). Out of seven crops, the CNF farmers obtained higher net value of output in four crops in the range of ₹15,942 per hectare in Bengal gram to ₹32,277 per hectare in Groundnut.

[2] For the sake of comparison, the biological stimulants/ inputs under CNF and agrochemicals under non-CNF, together, referred as plant nutrient and protection inputs (PNPIs)

0.3. Production efficiency of major crop under CNF

13. The elasticity analysis conducted across agroclimatic zones reveals key insights into how contextual factors, such as market strength, resource endowment, and crop diversity influence profitability in CNF relative to chemical/ non-CNF systems.
14. Resource poor zones need niche output market access and resource-rich regions, CNF farmers benefit from well-developed input markets.
15. A transition from monocropping to mixed cropping is vital across all zones. This agroecological shift enhances land use efficiency, promotes biodiversity, and supports sustainable profit growth.
16. A parallel analysis across marginal and small farmers reveals that inputs are generally used at or near optimal levels. Further increase of input use may not be a viable strategy for further profit growth
17. Elasticity estimates suggest that yield improvements alone do not significantly enhance profits unless accompanied by a change in cropping systems or farming practices.
18. For marginal and small farmers practicing CNF, the most promising gains lie in agroecological diversification, market access, and tailored resource support.

0.4. Family female labour use and production efficiency for major crops in CNF

19. The dynamics of family female labour use in crops like Paddy, Groundnut, and Black gram show diminishing returns once female labour surpasses an optimal level. This trend is most noticeable in CNF systems, which rely heavily on family labour, especially female labour, but fail to sustain productivity beyond a certain threshold.
20. The results indicate an inefficient use of family female labour. This also is also true under non-CNF.
21. Mixed cropping can help balance female family labour across different crops, reducing the burden on any crop and optimizing overall land and labour productivity.

0.5. Coordination of Family Labour and Crop Production Outcomes under CNF

22. The statistical results indicates that a coordinated family labour, involving both male and female family members working together, significantly improves family labour

productivity in CNF systems.

23. It was noted that using family labour, whether male or female, independently leads to diminishing returns on productivity. This highlights the importance of collective family labour rather than reliance on individual contributions, particularly in CNF systems.
24. Both capital investments (such as machinery) and biological inputs (such as organic fertilizers) contribute significantly to enhancing family labour productivity. Integrating these inputs with family labour is particularly effective in CNF systems, making them more productive and sustainable in the long term.
25. CNF farmers use family labour and capital more effectively to maintain hired labour productivity. In contrast, non-CNF systems rely heavily on capital inputs, substituting for family labour, which may result in less efficient outcomes when compared to CNF systems.
26. CNF systems, through coordinated family labour and efficient use of biological inputs and capital, show greater efficiency and sustainability in farm productivity compared to non-CNF systems. This indicates that CNF offers a more resilient and environmentally sustainable farming model.
27. Gender-balanced labour practices, with both male and female members working together, significantly boost productivity. Additionally, the research underscores the need for innovations in technology and mechanization to reduce the physical burden on women while enhancing overall farm efficiency.

0.6. Impact of CNF on inputs use and investment

28. Apart from improving the farming conditions, CNF has far more potential benefits in the form of soil/ natural resources conservation and their optimum utilization, optimum utilization of human resource, better human health, freedom and well-being of farmers.
29. It is noted in all previous surveys that farmers are continuously increasing the area allocation to CNF. The results of the present survey also indicate that the CNF farmers have increased area under CNF from 0.32 hectare in 2020-21 to 0.50. It may be worth mention here that, normally, the operated area may fluctuate from year to year owing to weather and other factors. But the farmers are increasing the area allocation to CNF continuously, not only in absolute terms, but also in relative terms. In the present context also, the CNF farmers have increased the area allocation to CNF from 45.2 percent of their operated area in 2020-21 to 53.9 percent in 2023-24 (Table 6.1).

30. The increase in area allocation to CNF indicates the potential benefits of CNF and growing farmers' interest and confidence in CNF. It also indicates the extent of land being regenerated.
31. The foremost intervention of APCNF is the replacement of agrochemicals with bio-stimulants.
32. On an average the CNF farmers avoided 5.07 quintals of fertilizers per hectare under S2S. These include 1.12 quintals of Urea and 1.03 quintals of Complexes of nitrogen (N), phosphorus (P), and potassium (K) (NPK); 0.81 quintals of Di-ammonium Phosphate (DAP) and 2.11 quintals of other fertilizers (Table 6.2).
33. On an average the CNF farmers avoided the expenditure of ₹14,352 per hectare on agrochemicals in their CNF fields. This includes ₹6,700 on fertilizers and ₹7,652 on pesticides, weedicides and others.
34. Various CNF practices are expected to soften the soil and increase the carbon content in the soil. These changes in turn would increase the water/ rainfall percolation into the soils and increase the water/ moisture holding capacity of the soils.
35. About 47 percent of CNF farmers have reported that water requirement for crop cultivation under CNF has reduced. But there are wide fluctuations in these percentages across the agroclimatic zones ranging from 13 percent in the Scarce rainfall zone to 86 percent in the HAT zone.
36. A considerable reduction in water requirement is perceived in Palm oil cultivation by 100 percent of farmers, Ragi (77 percent) Banana (67 percent), Paddy (39 percent), Cashew (33 percent), Chilies (30 percent) and so on. On the other hand, 100 percent of farmers cultivating Mango, Citrus, Red gram, other pulses, Coconut, Sesamum, Sugarcane and Onion reported a moderate reduction in water requirement (Figure 6.3).
37. CNF is requiring a greater number of labour days compared to that of non-CNF, in almost all crops and also on an average. At the same time, CNF is enabling households to utilize their labour, and also other agriculture assets, optimally during the off-season through PMDS and during trough periods through mixed and model crops.
38. CNF is utilizing more family labour. But there is no clear trend about gender wise changes in the labour use in CNF. As some of the agriculture operations are performed by both male and female members, their availability in a family determine gender-wise composition of labour use in some cases.
39. On an average, 17 additional days are used under CNF compared to non-CNF. These included 12 days of own labour and 6 days of hired labour; 8 are male labour days and

9 are female labour days (Table 6.4).

40. Furthermore, CNF is promoting and facilitating higher cropping intensity or 365 days crop cover. In such condition many agricultural operations gets scattered over a longer span of time. For example, if a farmer takes PMDS, he/ she will complete the land preparation in March instead of in June or July. In such scenarios, the CNF farmers can optimize their own labour use and also the use of their own agriculture machinery and implements, more productively.
41. It is conclusive that CNF needs not only more human labour, but also uses more family labour. However, it is not so obvious about the use of male and female labour. As the CNF is evolving, its need for male and female labour requirement is also evolving. Further, at the family level it is availability of labour that determine the labour use.
42. A greater number of labour days are utilized in all, but one operation, under CNF over non-CNF (Table 6.5).
43. The difference between CNF and non-CNF crops varies from minimum of one day in each of land preparation and sowing/ transplantation to maximum of five days in irrigation and four days each in Threshing and Supervision.
44. As CNF is evolving, it is being practiced as action research by the participants. Each farmer devotes relatively more time on supervision. It may be noted that CNF is encouraging and facilitating cultivation of mixed crops or cultivation a few minor crops/ plants along with the main crop, and also cultivation traditional crops like Red rice, Black rice, etc. Such practices would result in an additional care and efforts in the crop harvesting and threshing.
45. The CNF farmers saved 4 labour days in weeding and inter-cultivation. This finding is in line with the assertion of RySS- that the weed growth would be suppressed through 365 crops on the fields and also through mulching.
46. A noteworthy reduction in the paid-out cost of cultivation in almost all crops is expected to reduce the working capital requirements for CNF, which in turn, is expected to result in a reduction in the CNF farmers' borrowing for agriculture and other uses.
47. A noteworthy reduction in the paid-out cost of cultivation in almost all crops is expected to reduce the working capital requirements for CNF, which in turn, is expected to result in a reduction in the CNF farmers' borrowing for agriculture and other uses.
48. Nearly 93 percent of farmers reported a reduction in funds/ investment requirements for agriculture; and nearly 92 percent of CNF farmers perceived a reduction in borrowing for agriculture. Nealy 69 percent of famers reported a reduction in borrowings from

informal sources and 38 percent stated a reduction in the interest rates in the informal credit markets in their locations/ villages. Interestingly, relatively a higher percentage (22 percent) of CNF farmers perceived a considerable reduction in the borrowings from the informal sources, due to CNF (Figure 6.9).

49. Even the hard data collected from the farmers confirmed a considerable reduction in the borrowings for the cultivation. In every aggregated parameter with respect to borrowing, such as percentage of sample farmers borrowed, average borrowed amount, loan outstanding amount, etc., the CNF farmers fared better (Table 6.7).
50. In addition to borrowing less amount, the CNF farmers are able to repay a part of their loans. As a result, their loan outstanding amount is less than their borrowed amount at the time of the survey. On the other hand, the non-CNF farmers' loan outstanding is greater than their borrowed amount. Compared to the CNF farmers, the non-CNF farmers have relatively more long-standing loans. The average length of loan outstanding is 1.45 years for non-CNF farmers vis-à-vis 1.26 years for CNF farmers.

0.7. Issues, challenges and way forward

51. Nearly 96 percent of CNF farmers willingness to continue the CNF is remarkable phenomenon. This willingness continue with the CNF is spread almost evenly across all agroclimatic zones and each and every category of farmers (Figure 7.1).
52. Overwhelming majority of CNF farmers stated that there is a greater interest in CNF farming and food among different stakeholders. But only a handful of farmers received higher prices for CNF output.
53. CNF proved to be economically profitable and sustainable. Further, the program is expanding at a fast pace in the state due to the efforts of RySS.
54. However, voluntary replication by the farmers is tardy. Even converting the entire operated holding into CNF is also slow.
55. At the state level, 80 percent of farmers reported one problem or the other while adopting CNF. Compared to earlier studies, a greater number of farmers reported one problem or the other. The possible reasons could be integration of PMDS in CNF, expansion of the program, which may be resulting in more shortage of various inputs, including labour, increased marketing challenges due to increase in the CNF output, and shortage of extension services due to expansion of the program and shortage of staff, etc.
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57. Among all, problems related to supply of CNF stimulants/ inputs are more in number. About 59 percent of farmers reported that non-availability or shortage of suitable equipment and implements, such as blenders, drums, mostly for the preparation of CNF inputs as a major constraint. Another 44 percent of farmers reported non-availability of workers, including family members, who are willing to the prepare CNF inputs. Further, 51.4 and 33.1 percent of farmers mentioned scarcity of raw material and livestock for dung and urine for the preparation of CNF inputs as constraints, respectively (Figure 7.6).
58. Apart from the input supply related challenges, marketing of CNF output at a little higher price is major challenge cited by 58 percent of farmers. Further, scarcity of hired labour and own labour as constraints, are cited by 40.9 percent and 30.7 percent of farmers respectively. It may be worth mentioning that labour shortage is not an exclusive issue in CNF. Non-CNF farmers also often cite the same problem.
59. Though the coverage of CNF is expanding at fast pace, to cover the entire cropped area and all farmers in the state, out of the box strategies may have to adopted.
60. Still the bulk of state government's support to agriculture is going to non-CNF or chemical-based farming. Many CNF farmers question this.

0.7.1. Way forward

61. There is a need for larger budgetary allocation to the CNF
62. Various government incentive schemes may be integrated with CNF. For example, PMDS seed kits may be distributed instead of the kits of green manure crops. Similarly, CNF output may be procured for the public distribution systems (PDS), Midday Meal, Anganwadi Centers, Anna Canteens, Residential hostels, etc.
63. The services of the Agriculture Departmental extension persons may be obtained in the CNF GPs.
64. A 5 to10 percent price incentive over and above the Government of India's minimum support price may be given to CNF farmers. It could be a game changer.
65. As of now, the project is the only source of extension services. The project is also utilizing the services of SHG institutions to some extent. The project may also consider to involve other institutions like Panchayat Raj Institutions (PRIs), non-government

organizations (NGOs), local cooperatives, corporate bodies, etc., for the expansion of the program at an accelerated pace.

66. Appropriate tools for different CNF operations, especially for preparation of the stimulants, may be designed, developed and distributed.
67. A CNF input/ stimulant supplying shops may be promoted in each GP.

Chapter 1
Context, Objectives and Methodology

1.1. Introduction

To convert various challenges associated with the chemical-based agriculture into an opportunity to resolve the crises facing farmers,[3] the Government of Andhra Pradesh has adopted the natural farming, known as Andhra Pradesh Community Managed Natural Farming (APCNF, and in short CNF)[4]. APCNF is an ecological agriculture, based on the evolutionary principles of the nature.[5] The premise of APCNF is that the soil and atmosphere have all the required elements and nutrients for plant growth. There is no need to provide external inputs for plant growth and protection. For an example, we can turn to natural forests, which grow profusely and perpetually without any external inputs. What is needed is to catalyze those processes. To promote the program in the state, the Government of Andhra Pradesh have established "Rythu Sadhikara Samstha" (RySS), an integrated institutional mechanism. Apart from implementing the program in the state, RySS is leading large-scale action research to develop knowledge products and agriculture models in CNF. One of the major inventions by RySS is Pre-monsoon Dry Sowing (PMDS).

PMDS is a global breakthrough and the exact science of PMDS is yet to be determined. The enhancement of soil biology, through CNF practices and raising of multiple diverse crops as a mixed crop cultivation, creates some special conditions for the seed germination and plant survival during the dry seasons. In PMDS, mulching across the field acts as the catalyst to harness the water vapor from the atmosphere that drops to the land surface in the form of early morning dew. The material used for mulching facilitates the percolation of the dew into the

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[3] The challenges including higher and growing cost of cultivation, low and dwindling farm surpluses/ profits, mounting debts among farming community, health hazards for both producers and consumers, adverse impacts of climate change, etc., have been discussed in the previous reports. The reports can be accessed from https://www.idsap.in/reports.html and also from https://apcnf.in/category/reports/

[4] The words APCNF and CNF are used interchangeably in this report. Similarly, the words non-APCNF and non-CNF are used interchangeably.

[5] The universal principles of Natural Farming include: (1) Soil to be covered with Crops 365 Days (Living Root), (2) Diverse Crops and trees 15 -20 crops, (3) Increase organic residues on the soil, (4) Bio-stimulants as necessary catalysts, (5) Minimal Disturbance of Soil, (6) Integrate animals in to farming, (7) Use indigenous seed, (8) Pest management through botanical extracts, and (9) No synthetic fertilizers, pesticides and herbicides. See https://apcnf.in/#

soil and prevents its evaporation again. The farmers are, therefore advised to follow PMDS during March-May/June, followed by Kharif crops, Pre-Rabi dry sowing (PRDS) and Rabi crops, under the overall CNF program. Farmers are expected to get multiple benefits through the crops grown under PMDS and PRDS that include obtaining intermittent cash income, food items, green manure, and green fodder to animals. Thus, PMDS contributes to cropping intensity, increased agricultural incomes, and continuous green cover to the soil for 365 days in a year. In turn, these practices would result in improvements in soil fertility besides reducing and/ or removing greenhouse gases (GHG) emissions and capturing the water vapor from the atmosphere. Hence, RySS has made PMDS as an integral part of CNF, this study is mandated to select CNF sample farmers from those farmers, who grew PMDS during March-July 2023 and grew Kharif crops in 2023-24 season. These farmers are known as PMDS+CNF farmers[6].

1.2. The study and objectives

RySS has assigned the present study - "Assessing the impact of CNF 2023-24" to Institute for Development Studies Andhra Pradesh (IDSAP). This is in continuation of earlier studies by Centre for Economic and Social Studies (CESS) in 2018-19 and by Institute for Development Studies Andhra Pradesh (IDSAP) since 2019-20.[7] IDSAP has been acquiring expertise and experience in the conduct of the study and improving the methodology over the years. Further, IDSAP has access to the earlier years' data, to use wherever it is necessary. The study has two lines of enquiries, viz., panel study and cross section study. In the panel study, we are surveying the same set of 260 (panel) sample farmers across all districts, since 2018-19. The number of panel farmers was enhanced to 390 in 2019-20 and further, to 430 in 2023-24. The panel study, as a chapter, is included in the final report of each year. This year also, the panel study component, as a separate chapter, will be included in the final report. On the other hand, the cross-section study is the major component in each year study, covering about 1,100 to 1,400 CNF farmers and 650 to 850 non-CNF farmers, who are selected separately each year. The cross-section study is an annual study involving two surveys of Kharif and Rabi seasons of same set of the sample households in two seasons. The results are covered in three research reports viz., (1) First interim report related to the Kharif season, (2) Second interim report related to the Rabi season, and (3) Final report. This is the second interim report, and broadly

[6] The words 'PMDS+CNF' and 'CNF' are also used interchangeably in this report.

[7] Almost the same team is conducting the studies since 2018-19. While, the first-year study was based at Centre for Economic and Social Studies (CESS), Hyderabad [https://cess.ac.in/], IDSAP [https://idsap.in/index.html] has been anchoring the studies since 2019-20.

covers the Rabi season of agriculture year 2023-24.

The overall objectives of the annual study are: (1) to make a comparative assessment of the outcomes of CNF practices of cultivation vis-a-vis the chemical-based agriculture practices, which are referred as non-CNF. The outcomes include cost of cultivation, crop-yields, gross and net returns. (2) to understand the transformative potential of CNF through a panel study. The specific objectives of the present report are detailed below.

1. To assess the impact of CNF on the farming conditions, such as cost of cultivation, crop-yields, crop output prices, value of crop output at the state level during Rabi 2023-24.
2. To evaluate the impact of CNF on farming conditions for different agroclimatic zones and across farmer categories.
3. To assess the contribution of family female labour to agricultural production and productivity for different crops.
4. To examine the contribution of coordinated family labour to family labour productivity, hired labour productivity and crop productivity
5. To appraise the impact of CNF on input use in farming and related changes.
6. To review the issues and challenges in implementation of the program, and
7. To provide insights to ease the implementation of the program.

1.3. Methodology

1.3.1. The Basic Approach

This study is a continuation of the previous studies – "assessing the impact of CNF", conducted in 2018-19, 2019-20, 2020-2021, 2021-22 and 2022-23 on APCNF.[8] The study has used the "***with and without***" method to assess the impact of CNF in the cross-section analyses. In this method the outcomes of CNF farmers, cultivating a particular crop are compared with the outcomes of the non-CNF farmers cultivating the same crop, but using chemical inputs or non-CNF method. Costs and returns data for the crops considered for the analysis were obtained from the farmers through household survey. Crop Cutting Experiments (CCEs) have been conducted to assess the yields of the selected crops of both CNF and non-CNF farmers scientifically and independently.

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[8] All the study reports can be accessed from https://www.idsap.in/reports.html

The study covered 10 major crops that are identified based on the cropped area in the state. For these 10 crops, detailed costs, yield and returns data are collected and analyzed. The crops include: (1) Paddy, (2) Groundnut, (3) Cotton, (4) Bengal gram, (5) Black gram, (6) Maize, (7) Red gram, (8) Chillies, (9) Green gram and (10) Ragi. While the first nine are cultivated on largest areas in the state, the last one is selected as a special case. These ten crops together are cultivated on 54.7 lakh hectares in the state, which was equal to 74.39 percent of gross cropped area (GCA) [73.53 lakh hectares] in the state, during the quinquennial ending with 2022-23. But owing to long duration of harvesting period and challenges of conducting the multiple picks of CCEs for a longer period, the Chillies crop was dropped in the Kharif period survey.

1.3.2. Selection of sample GPs and households

In the past we used to select CNF (treatment) sample Gram Panchayats (GPs) from the list of CNF GPs, provided by RySS, where PMDS plus CNF are practiced. Then we use to select the non-CNF (control) sample GPs from the rest of the GPs in the state, where CNF is yet to be implemented. In this process we used to get a quite dispersed CNF and non-CNF sample GPs, at times, with a bit of different socio-economic and geographical conditions. ***It was planned to select both CNF and non-CNF GPs from the same set of mandals to minimise these variations between the CNF and non-CNF sample.*** The CNF program has reached about 30 percent of GPs and almost all rural mandals (640 mandals), in the state. Needless to say, the program has covered all the six agroclimatic zones and all districts in the state.

As shown in the Table 1.1, the study was mandated to cover 264 GPs consisting of 130 CNF GPs, 78 non-CNF GPs and 56 panel GPs. In case of panel GPs, 52 GPs were selected in 2018-19 and 2019-20 are survey again in 2023-24. Further, four more GPs from the erstwhile Anantapuramu district, i.e., two from new Anantapuramu and two from Sri Satya Sai district, which have considerable number of A-grade and any time money (ATM) model farmers, were selected. As these models get increasingly integrated with CNF, it was planned to include some of the A-grade and ATM model farmers in the panel list. But the notable change introduced in this year study methodology is the selection of CNF and non-CNF GPs from the same set of mandals, where PMDS+CNF is practiced. Out of 640 CNF mandals, 78 mandals were selected randomly from 26 districts. These sample mandals were allocated to 26 districts in the proportion of CNF farmers in each district, subject to a minimum of one mandal from each district irrespective of number of CNF farmers in each district. After selection of sample mandals, two separate lists of CNF and non-CNF GPs were prepared from these mandals. From the list of non-CNF GPs, one GP is selected randomly from each sample mandal. If any mandal is saturated with CNF, one non-CNF GP is selected from an adjoining mandal. From the list CNF GPs, two GPs were selected randomly from each of 52 sample mandals with highest number of CNF farmers. One CNF GP are selected randomly from remaining 26 sample mandals, subject to selection of a minimum of two CNF GPs per each district.

In each selected GP, a list of all cultivators is prepared through a listing survey along with information required for deciding the eligibility of cultivator for the survey. The criterion for eligibility is 1) practicing both PMDS+CNF and 2) cultivating any of the identified major crops either in Kharif and/ or in Rabi season. In CNF GPs, each house is visited. But some of the houses are skipped, in the middle of survey, (1) if they did not cultivate any land during year, (2) if they did not practice PMDS during the reference period, (3) if they did not practice CNF on the PMDS plot, and (4) if they did not cultivate any of 10 sample crops under CNF on PMDS plot.

In case of non-CNF GPs, the household listing is limited to 250 to 300 households. If any GP has less than 300 households, all households in that GP are listed. If any GP has around 400 households, about two-thirds or two out of every three of houses are listed. If any GP has around 500 households, one in every two houses is listed. If any GP has around 1,000 households, one in every four houses were listed. If any GP has 5,000 households, one in every 20 houses were listed, and so on.[9]

Table 1.1: Category wise number of sample GPs and households

Category of Sample	No. of sample GPs	No. of sample households	Allocation criterion
CNF	130	1,300	Number of CNF farmers @ 10 per GP
Non-CNF	78	780	@ 10 non-CNF farmers per GP
Panel	56	430	Previously selected
Total	264	2,510	

[9] Needless to say, the initial numbers/ number, in each cluster of houses, are picked randomly.

The mandated total number of sample households (HHs) or farmers[10] is 2,510, including 1,300 CNF (cross-section) farmers, 780 non-CNF farmers and 430 panel farmers (Table 1.1). It is proposed to select 10 sample farmers per GP. As the study is focused on crop wise detailed analysis of selected 10 crops, the sample selection process is influenced by the prevalence of the selected crops in the sample GPs. On an average more than 100 CNF sample farmers and about 100 non-CNF sample farmers are selected for each of the select 10 crops, subject to availability of the same in the listing data. It is quite possible that in this procedure a cultivator selected for one crop may also be selected for another crop. All such duplicate cultivators are deleted from the final set of sample cultivators. Further, the study made efforts to maintain a balance between CNF and non-CNF sample in the ratio of 5:3, not only at the state level, but also at the agroclimatic zonal level. For the sake of this, the study has increased the total CNF and non-CNF sample size. However, availability of the adequate number of sample observations in some crops and cultivation of more than one selected crops by the sample farmers have affected, to a limited extent, the balance in the ratio of CNF and non-CNF crops' observations, especially at the agroclimatic zones.

1.4. Sample size

A total of 1,348 CNF and 842 non-CNF samples are selected for the study and surveyed during both Kharif and Rabi seasons of 2023-24. In addition, 245 Panel 1 (selected 2018-19) farmers, 130 Panel 2 (selected in 2019-20) and 40 new Panel farmers (selected in 2023-24) were surveyed during the reference period. These are greater than originally planned sample size. However, a greater number of samples are selected to ensure that at least 70-80 sample observations are available in respect of each crop at the state level and 30-40 at the zonal level, in 5:3 ratio. As mentioned above that availability of the adequate number of sample observations in some crops and cultivation of more than one selected crop by the sample farmers have affected, to a limited extent, the balance in the ratio of CNF and non-CNF crops' observations, especially at the agroclimatic zones. Distribution of sample CNF and non-CNF farmers across all agroclimatic zones of the state, size-classes, tenure categories and social categories are shown in the Table 1.2 and Figure 1.1.

[10] Except in chapter 2, the words 'sample households' and 'sample farmers' are used interchangeably in the rest of the report.

It may be noted that the state has six different agroclimatic zones. The sample observations are spread across all the zones, with the Scarce rainfall zone accounting for the maximum number, with 22 percent of CNF (369) farmers and 26 percent of non-CNF (318) farmers. The least number of observations is from the Godavari zone with just 7 and 6 percent of CNF and non-CNF farmers. Due representation is given to the gram panchayats/mandals while selecting the sample as practiced in the previous years' studies.

Table 1.2 also shows the distribution of sample observations by size-class of farmers. As in the universe, the marginal farmers outnumbered the others. They account for 69 percent in CNF farmers and 61 percent of non-CNF ones. The table also shows data for tenure groups. As expected, tenants are few among the sample observations, as in the universe in case of both CNF and non-CNF sample. Pure tenants[11] account for 2 percent and 3 percent in CNF and non-CNF sample respectively. However, the percentage of owner-tenant[12] farmers is higher in CNF farmers (5%) compared to 3 percent in non-CNF farmers. On the whole there is no considerable difference in the composition of different tenurial categories in CNF and non-CNF sample farmers. The tenurial categories data doesn't support the assertion that CNF, which needs some time to build the soil quality and become profitable, is not suitable for tenant farmers, who do not have long term land-rental agreements. Table 1.2, as well, gives the distribution of sample observations classified by social categories. Scheduled cates (SC) and scheduled tribes (ST) together account for 27 and 25 percent in CNF and non-CNF samples respectively. As mentioned above, this year the CNF and non-CNF sample are drawn from same mandals. The overall data in Table 1.2 suggest that the efforts to reduce the differences in the socio-economic profiles of project and control sample proved to be successful. Still the data indicates that the poor and marginal sections such as marginal farmers, tenant farmers (especially owner-tenant) farmers and SC and ST farmers have a higher representation in the CNF sample, albeit marginally. Further, the distribution of the panel farmers indicates that the poor and vulnerable sections were in good number in the initial years of APCNF. Gradually other sections are joining the program.

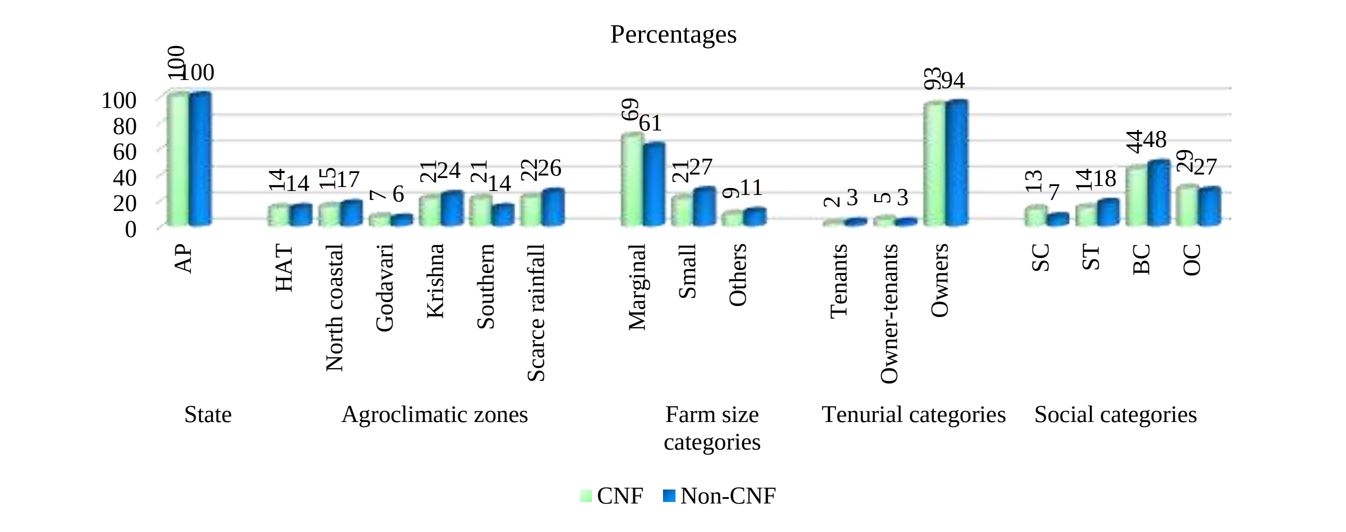
[11] Pure tenants or tenants are the farmers, who do not own any land, but cultivate the lease-in land.
[12] Owner-tenant farmers are the farmers, who own some land and cultivate lease-in land.

Table 1.2: Sample size of different agroclimatic zones and farmers' categories

Geographic units & Farmer categories		Number			Percentage share		
		CNF	Non-CNF	Panel	CNF	Non-CNF	Panel
State	AP	1,348	842	415	100	100	100
Agroclimatic zones	HAT	194	118	31	14	14	7
	North coastal	201	139	58	15	17	14
	Godavari	95	49	56	7	6	13
	Krishna	280	199	88	21	24	21
	Southern	282	122	85	21	14	20
	Scarce rainfall	296	215	97	22	26	23
Farm size categories	Marginal	931	517	259	69	61	62
	Small	289	229	87	21	27	21
	Others	128	96	69	9	11	17
Tenurial categories	Tenants	29	26	7	2	3	2
	Owner-tenants	61	24	26	5	3	6
	Owners	1,258	792	382	93	94	92
Social categories	SC	169	61	63	13	7	15
	ST	195	150	84	14	18	20
	BC	589	402	176	44	48	42
	OC	395	229	92	29	27	22

Source: APCNF Field Survey 2023-24

Figure 1.1: Percentage of share of CNF and non-CNF sample across different agroclimatic zones and farmers' categories in 2023-24



Source: IDSAP, Field Survey 2023-24

1.5. Crops Covered and Crop Cutting Experiments

As mentioned above, the study proposed to cover ten crops for the detailed costs and returns analyses during the year. Because of seasonal factors, the present second interim (Rabi) report covers seven crops, viz. (1) Paddy, (2) Groundnut, (3) Bengal gram, (4) Maize, (5) Black gram, (6) Green gram and (7) Ragi, which mostly cultivated during the Rabi season in the state. Though Ragi is mostly cultivated in the Kharif season, we got a reasonable number of observations and CCEs for Ragi, especially for CNF farmers, during the Rabi 2023-24 also. Therefore, it is included Ragi in the report.

The Crop Cutting Experiments (CCEs) were conducted scientifically to get an independent estimate of crop yields under CNF and non-APCNF. It is to be noted that the study has adopted standard methodology of Indian Agricultural Statistical Research Institute (IASRI), which is followed by National Statistical Office (NSO, formerly known as NSSO) and Directorate of Economics and Statistics (DES) of all states, including Andhra Pradesh, for conducting CCEs. Crop wise number of CCEs are given in Table 1.3. In total 1,498 CCEs were conducted for all crops covered. These include 1,235 for cross-section farmers and 263 for panel farmers. The cross-section CCEs include 808 CCEs for CNF crops and 427 for non-CNF crops. The crop wise CNF CCEs vary from 37 for Green gram to 229 for Paddy. The same for non-CNF vary from 16 for Ragi 118 for Black gram. In case the panel farmers, the number of CCEs vary 6 for Ragi and 9 for Groundnut to 82 for Paddy and 77 for Black gram. In this context it is worth mentioning that CNF farmers are widely cultivating the food crops, especially Paddy, apparently for own consumption and to share with their near and dear. As a result, it is observed that Paddy is more widely cultivated by the CNF farmers. In other words, the cropping pattern of CNF and non-CNF farmers are observed to be different, even though we selected the sample based the uniform cropping patterns. Needless to say, these CCEs add immense value to the study as these are conducted, independently by IDSAP, a third party, using the scientific method, which is being used by almost all official agencies.

Table 1.3: Crop wise number of CCEs conducted for cross-section and panel farmers during Rabi 2023-24 (in number)

Crop	CNF	Non-CNF	Total cross-section	Panel	Grand total
Paddy	229	65	294	82	376
Groundnut	63	39	102	9	111
Bengal gram	124	99	223	17	240
Maize	128	60	188	45	233
Black gram	174	118	292	77	369
Green gram	37	30	67	27	94
Ragi	49	16	65	6	71
Other crops	4	0	4	0	4
Total	808	427	1,235	263	1,498

Source: APCNF Field Survey 2023-24

1.6. Data Collection and Management Process

In all, five research tools, viz. (1) Household listing schedule for the CNF GPs, (2) Household listing schedule for the non-CNF GPs, (3) Questionnaire for CNF households, (4) Questionnaire for non-CNF households, (5) Schedule to record the CCE related details, were used before the present season survey. In the survey related to present report. the Kharif CNF and non-CNF households' schedules were revised and customized to suits the farming conditions in Rabi season. In addition, the same CCE schedule was used in the Rabi season survey. The field team was given online appropriate training about the Rabi questionnaires. Further, supportive field manual with instructions and clarification for all questionnaires, has been provided to the field team. As mentioned in the first interim report, the field staff was placed continuously in the field in their allotted districts in order to track the farming and related activities of sample households throughout the year. Each sample farmer was visited about six times by the field staff to collect data about farmer household's details and farming details throughout the agriculture year (AY) 2023-24. The Rabi data was collected during November 2023 to May 2024. As per the design, each sample farmer was visited a minimum of two times during the season to collect household and farming data and to conduct the Crop Cutting Experiments (CCEs). Senior team members, known as Regional Supervisors (₹), have visited the field and cross-checked the filled in information and participated in data collection processes. They also visited farmers' fields, especially the model farmers, innovative farms and social entrepreneurs, to prepare the case studies.

The field data was digitalized with the support of "i for Development (i4D) Parishkaar Technologies Ltd", Hyderabad. Each field staff was given a Tab to enter the data, through the exclusively developed Android based Application (App). The data was processed with R and excel software. In this report, we have used cross-section sample households' data collected from CNF and non-CNF farmers and the results of the corresponding CCEs conducted during the Rabi season. Descriptive statistics such as averages, percentages, etc., have been worked out. Cross tables have been prepared and used in the report. Appropriate econometric analysis is carried out. The data is analyzed at the state level, agroclimatic zones[13] wise and farmers categories[14] wise.

1.7. Structure of the Report

The context, objectives and methodology of the study have been presented in Chapter 1. Chapter 2 consists of the comparative analyses between the CNF and non-CNF farmers with regard to the changes in expenditure on plant nutrient and protection inputs (PNPIs)[15], paid-out costs, crop yields, gross and net values of output, at the state level. The impact of CNF on the farming conditions of major crops, covered in the report, across the agroclimatic zones, and farmers categories are covered in Chapter 3. Chapter 4 contains an econometric analysis of family female labour contribution to agricultural production and productivity under CNF and non-CNF for different crops. The analysis of intrahousehold coordination of family labour and its impact on family labour productivity, hired labour productivity and crop yield under CNF and non-CNF is explored in Chapter 5. The impact of CNF on farm inputs uses are covered in Chapter 6. The issues and challenges, encountered by the farmers in adoption of

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[13] A list of agroclimatic zones and their demarcations are shown at the appendix 1 below.

[14] Farmers are organized in three different categories, viz., **farm size categories** consist of marginal farmers (< 1 hectare), small farmers (1 to 2 hectares) and other (consist of medium [2-4 hectares] and large farmers [4 and above hectares]) farmers; **tenurial categories** consist of pure or landless tenants, owner-cum-tenants and owner farmers; and **social categories** consists of SC, ST, BC and OC categories.

[15] For the sake of comparison, the biological stimulants/ inputs under CNF and agrochemicals under non-CNF, together, referred as plant nutrient and protection inputs (PNPIs)

CNF; and by the Project in implementing the program, are discussed in Chapter 7. Apart from these four chapters, an Executive Summary is also presented at the beginning of the Report.

Appendix 1: List of Agroclimatic zones and their demarcation

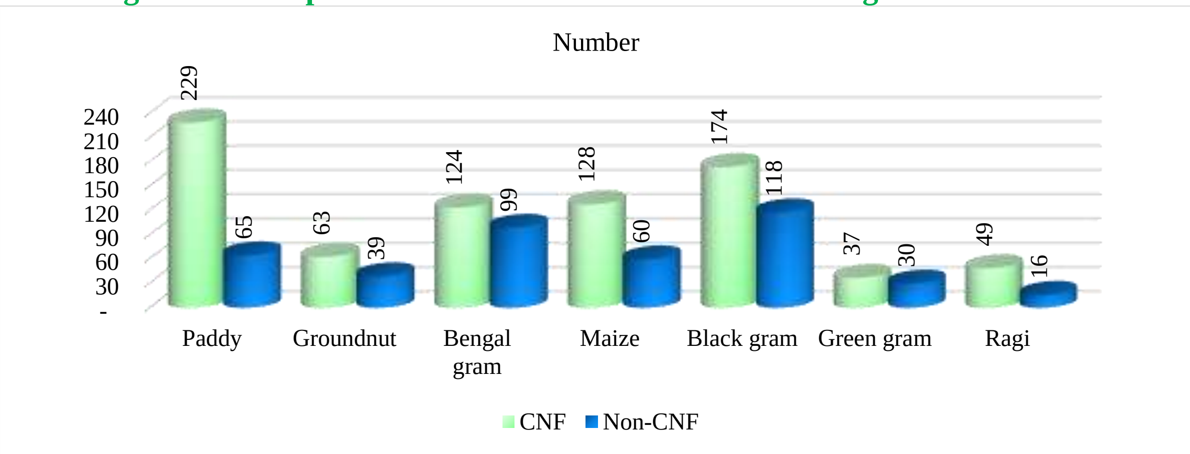
Zone	District	Mandals
1. High Altitude Tribal (HAT) Zone	Srikakulam	Hiramandalam, Kothuru, Mandasa, Meliyaputti,Pathapatnam Sarvakota.(6)
	PVP Manyam	Bhamini, Gummalakshmipuram, Komarada, Kurupam, Makkuva, Pachipenta, Parvathipuram, Saluru, Seethampeta. (9)
	ASR	All the mandal of ASR (22)
	Total	37
2. North-coastal Zone	Srikakulam	Amudalavalasa, Burja, Etcherla, G. Sighadam, Gara, Ichchapuram, Jalumuru, Kanchili, Kaviti, Kota Bhommali, Laveru, Laxminarsu Peta, Narsanna Peta, Palasa, Polaki, Ponduru, Ranasthalam, Santha Bhommali, Sarubujjili, Sompeta, Srikakulam, Tekkali, Vajrapukothuru. (23)
	PVP Manyam	Balijipeta, Garugubilli, Jiyyammavalasa, Palakonda, Seethanagaram, Veeraghattam (6)
	Visakhapatnam	All mandals of Visakhapatnam (11)
	Anakapalli	All the mandal of Anakapalli (24)
	East Godavari	Nandigam (1)
	Vizianagaram	All mandals of Vizianagaram (27)
	Total	92
3. Godavari Zone	East Godavari	All mandals of East Godavari (19)
	West Godavari	All mandals of west Godavari (19)
	Eluru	Bheemadole, Buttayagudem, Chintalapudi, Denduluru, Dwarakatirumala, Eluru, Ganapavaram, Jandareddigudem, Jeelugumilli, Kamavarapukota, Koyyalagudem, Kukunoor, Lingapalem, Nidamarru, Pedavegi, Peddapadu, Polavaram, T Narsapuram, Unguturu, Velairpadu. (20)
	Kakinada	All mandals of Kakinada (21)
	Konaseema	All Mandala of Konaseema (22)
	Total	101
4. Krishna Zone	Bapatla	All Mandals of Bapatla (25)
	Eluru	Agiripalli, Chatrai, Kaikaluru, Kalidindi, Mandavalli, Mudinepalle, Musunuru, Nuzividu. (8)
	Guntur	All mandals of Guntur (18)
	Krishna	All mandals of Krishna (25)
	NTR	All mandals of NTR (20)
	Palnadu	All mandals of Palnadu (28)
	Prakasam	All mandals of Prakasam (38)
	SPSN (Nellore)	Gudluru, Lingasamudram, Ulavapadu, Voletivaripalem. (4)
	Total	166
5. Southern zone	Annamayya	All mandals of Annamayya (30)
	Chittoor	All mandals of Chittoor (31)
	SPSN (Nellore)	All mandals of Sri Potti Sriramulu Nellore except Gudluru, Lingasamudram, Ulavapadu, Voletivaripalem (34)
	Tirupati	All mandals of Tirupati (34)
	Y S R Kadapa	All mandals of Y S R Kadapa (36)
	Total	165
6. Scarce rainfall Zone	Anantapuramu	All mandals of Anantapuramu (31)
	Kurnool	All mandals of Kurnool (26)
	Nandyala	All mandals of Nandyala (29)
	SSS	All mandals of Sri Satyasai (32)
	Total	118
AP	Total	679

Chapter 2
Impact of CNF on the farming conditions

2.1. Introduction

This chapter covers the economic impact of CNF. That is the chapter deals with changes in cost of cultivation, crop yields, output prices, and gross and net value of crop out due CNF during the Rabi season of 2024-25. As mentioned in chapter one, the major difference between CNF and non-CNF is the use of the plant nutrient and protection inputs (PNPIs). While CNF farmers apply natural stimulants and related method, which are organic (healthy and pollution free), inexpensive, and locally available, for plant growth and protection; the non-CNF formers use chemical fertilizers and pesticides, which are inorganic (unhealthy and pollutants), expensive and non-local inputs, for the same purpose. As a results, both the methods lead to different outcomes. This chapter aims at analyzing these outcomes, including PNPIs, paid-out costs, structure of paid-out costs, crop yields, output prices, gross value of output, and net value of output. A Comparative analysis is taken up between the CNF and non- CNF for seven crops, viz., (i) Paddy, (ii) Groundnut, (iii) Bengal gram, (iv) Maize, (v) Black gram and (vi) Green gram and (vii) Ragi. The study obtained reasonably good number of observations and consequently good number of CCEs for each of the crop covered, to provide robust results. Crop wise number of CCEs conducted during the study period are shown in Figure 2.1. The crop wise CNF CCEs vary from 37 for Green gram to 229 for Paddy. The same for non-CNF vary from 16 for Ragi 118 for Black gram.

Figure 2.1: Crop wise number of CCEs conducted during Kharif 2023-24



Source: IDSAP, Field Survey 2023-24

2.2. Plant Nutrient and Protection Inputs (PNPIs)

Plant Nutrition (PN) is very much necessary for the plant growth and yields, whereas the protection inputs (PI) used by the farmers to protect against diseases, insects, weeds, etc. Both these two aspects are very essential to get good quality and quantity of harvest. Both the CNF and non-CNF farmers used two different methods. In case of CNF, PNPIs means, as noted earlier, Beejamrutham, Dravajeevamrutham, Ghanajeevamrutham, Kashayams and Asthrams. These are prepared with cattle-dung and cattle-urine; and other locally available raw material such as leaves, tobacco, garlics, sour-buttermilk, and other materials. Needless to say, they cost very little, and locally available. But PNPIs under non-CNF include fertilizer, pesticides and weedicides are costlier. The average expenditure of ₹5,975 per hectare on PNPIs under CNF is considerably low compared to that of non-CNF, which is ₹14,352per hectare.

Table 2.1: Crop wise expenditure on PNPIs[@] under CNF and non-CNF and their difference during Rabi 2023-24

Crop	CNF	non-CNF	Difference between CNF & non-CNF		Significant
	₹/hectare		₹/hectare	in %	
Paddy	6,577	13,333	-6,756	-51	**
Groundnut	11,455	25,795	-14,340	-56	**
Bengal gram	7,933	18,717	-10,784	-58	**
Maize	5,702	22,816	-17,114	-75	**
Black gram	2,118	6,240	-4,123	-66	**
Green gram	3,142	7,304	-4,162	-57	**
Ragi	1,005	1,459	-455	-31	ns
Average[$]	5,975	14,352	-8,377	-58	

[@] PNPI means plant nutrients and protection inputs, which include the biological inputs/ practices in CNF and agrochemicals in non-CNF

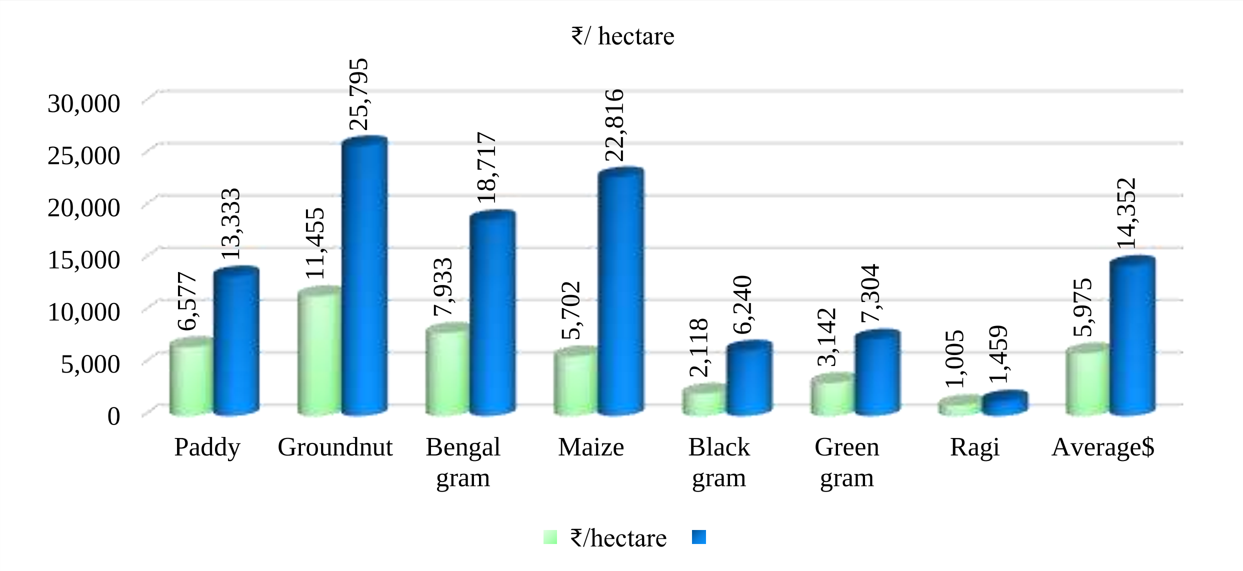
[$] *Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP*

***Significant at 1%; *Significant at 5%; ns= Not significant*

Source: IDSAP Field Survey, 2023-24

On average, the CNF farmers saved ₹8,377 per hectare in PNPIs compared to that of non-CNF farmers. The savings are equal to 58 per cent of non-CNF farmers' expenditure on PNPIs (Table 1.1). This is true across all the major crops covered in this report. The difference is statistically significant in all crops, except Ragi, which is cultivated with very few agrochemicals under non-CNF. Thus, it is evident that the CNF farmers could save considerable expenditure on PNPIs. This method enriches not only to soil health but also increase the incomes of the CNF farmer. Thus, CNF brought convergence between the interests of the farmer and the land.

Figure 2.2: Crop wise expenditure on PNPIs@ under CNF and non-CNF in Rabi 2023-24



[@] PNPI means plant nutrients and protection inputs, which include the biological inputs/ practices in CNF and agrochemicals in non-CNF
[$] Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP
Source: IDSAP Field Survey, 2023-24

2.3. Paid-out Costs

In addition to PNPI costs, both CNF and non-CNF farmers invest a lot on different inputs and agriculture operations, such as seeds, Farm Yard Manure (FYM), including penning[16]. The farmers also spend money on human labour, bullock labour, machine labour, implements and irrigation. In this study, the monetary values of all these items, including own and purchased/ hired items and values of own and purchased PNPIs are included in the paid-out costs of cultivation. But the value of family labour is not included in the paid-out costs. The paid-out cost used in the study is close to cost concept of "A1" under Farm Management Surveys. The data reveals that the paid-out costs are invariably lower under CNF than those of under non-CNF in all, but one, crops. Further, the difference is statistically significant in five out of six crops, in which the paid-out costs are less under CNF. In all these five crops, CNF farmers have considerable savings ranging from ₹4,415 per hectare in Black gram to ₹18,157 in Maize; and in relative terms it varies from 11 percent in Groundnut to 28 percent in Maize. In two crops viz., Green gram and Ragi,

[16] penning means keeping livestock, particularly the small ruminants in the field for their dung/ droppings The livestock owner gets some payment either in the form of cash or kind for this service.

the difference in the paid-out costs are statistically not significant. In Green gram, the paid-out cost is less under CNF by ₹6,677 (22 percent) per hectare and in Ragi the paid-out cost under non-CNF is less by ₹983 (14 percent) per hectare (Table 2.2). On average, the CNF farmers saved ₹7,534 per hectare in their paid-out costs. It is equal to 17 percent of the paid-out costs of non-CNF farmers. Compared to previous Kharif results, the savings obtained in paid-out costs in Rabi, are on higher side. Normally, the farmers in the state make relatively more investment in Rabi cultivation compared to Kharif season under non-CNF, especially, in high value crops like Maize, Paddy, and Groundnut. Hence higher savings in paid-out costs under CNF are possible. Other possible reason could be that the farmers might be reporting their PMDS costs as the expenditure on green manure under CNF Kharif season, which might have increased the paid-out costs under CNF.

Table 2.2: Crop wise paid-out cost under CNF and non-CNF and their difference during Rabi 2023-24

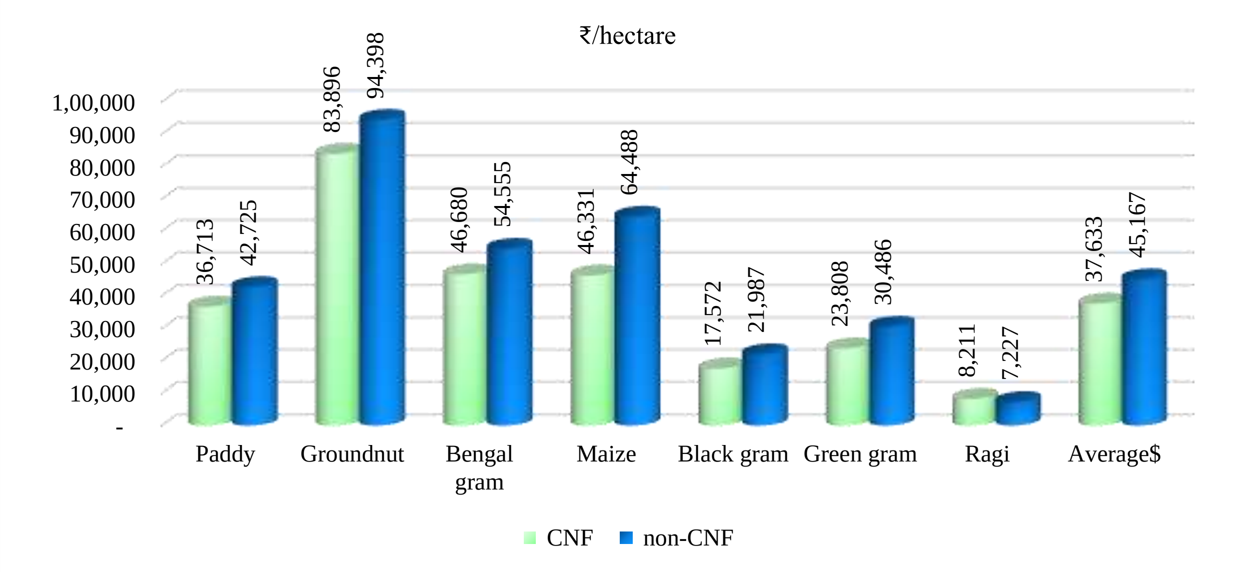
Crop	CNF	non-CNF	Difference between CNF & non-CNF		Significant
	₹/hectare		₹/hectare	in %	
Paddy	36,713	42,725	-6,012	-14	*
Groundnut	83,896	94,398	-10,502	-11	*
Bengal gram	46,680	54,555	-7,875	-14	**
Maize	46,331	64,488	-18,157	-28	**
Black gram	17,572	21,987	-4,415	-20	**
Green gram	23,808	30,486	-6,677	-22	ns
Ragi	8,211	7,227	983	14	ns
Average$	37,633	45,167	-7,534	-17	

$ *Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP*

***Significant at 1%; *Significant at 5%; ns= Not significant*

Source: IDSAP, Field Survey 2023-24

Figure 2.3: Crop wise paid-out cost under CNF and non-CNF during Rabi 2023-24



$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP
Source: IDSAP Field Survey, 2023-24

2.3.1. Structure of paid-out costs

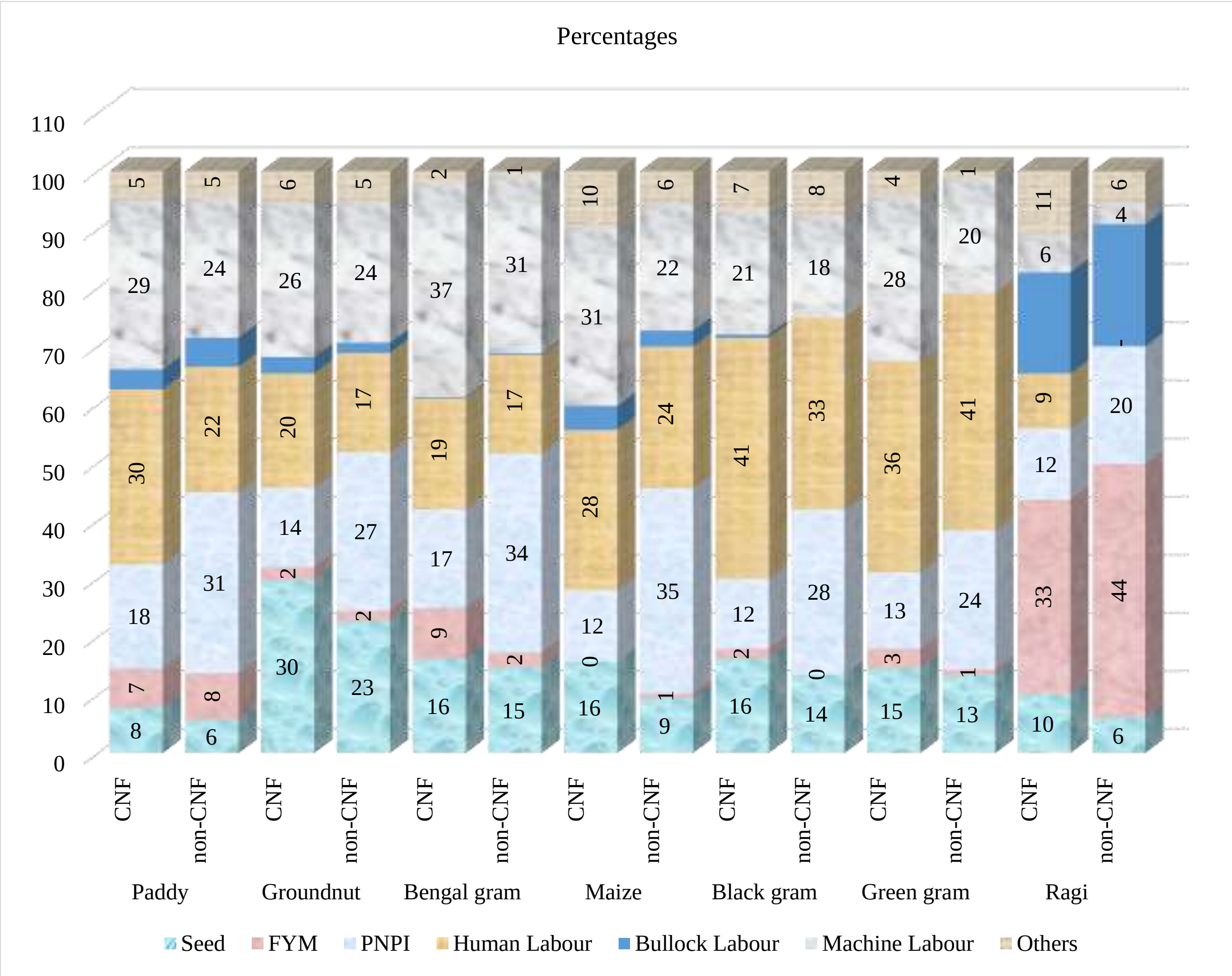
Crop wise data was collected for nine major agricultural inputs to know the impact of CNF on the structure of paid-out costs. Out of these nine inputs, six inputs, viz., seeds, farm yard manure (FYM), PNPIs, human labour, bullock labour and machine labour account for the lion's share of the paid-out costs for all crops ranging from 89 percent to 99 percent of paid-out costs.[17] Remaining three items, viz., implements, irrigation and miscellaneous together account for a smaller proportion in the paid-out costs. Therefore, these three items are clubbed together and referred as others. The share of PNPI is lower in paid-out cost in case of CNF compared to that of non-CNF consistently across all crops. On the other hand, the shares of human labour and machine labour under CNF are higher than that of non-CNF in all crops. This is obvious. It is interesting to see that the share of seeds is higher under CNF, in all crops. One possible reason could be that CNF farmers might be using traditional high value varieties like Red rice, Black rice, etc. In case of Ragi crop, FYM and bullock labour are major cost items under both CNF and non-CNF. However, CNF farmers have more diversified cost structure in Ragi. In fact, CNF farmers incurred relatively more expenditure on other items in almost all crops (Table 2.3 and Figure 2.4). It indicates a more diversified cost structure.

[17] In fact, only four items, viz., seed, PNPIs, human labour and machine labour account major portion of paid-out cost in all crops, but Rag.

Table 2.3: Percentage share of major inputs in the paid-out costs of sample crops in Rabi 2023-2024

Input	Paddy		Groundnut		Bengal gram		Maize		Black gram		Green gram		Ragi	
	CNF	Non-CNF	CNF	Non-CNF	CNF	Non-CNF	CNF	Non-CNF	CNF	Non-CNF	CNF	non-CNF	CNF	Non-CNF
Seed	8	6	30	23	16	15	16	9	16	14	15	13	10	6
FYM	7	8	2	2	9	2	-	1	2	-	3	1	33	44
PNPI	18	31	14	27	17	34	12	35	12	28	13	24	12	20
Human Labour	30	22	20	17	19	17	28	24	41	33	36	41	9	-
Bullock Labour	3	5	3	2	0	0	4	3	1	-	-	-	17	21
Machine Labour	29	24	26	24	37	31	31	22	21	18	28	20	6	4
Others	5	5	6	5	2	1	10	6	7	8	4	1	11	6
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Figure 2.4: Percentage share of major inputs in the paid-out costs of sample crops in Rabi 2023-2024



2.3.2. Composition of paid-out costs in absolute terms

As mentioned above that when the share of PNPIs decline in CNF, the share of other major components such as human labour and machine labour would increase. It is obvious and observed in all crop. But the actual (absolute) expenditure did not increase on these items. Crop wise absolute expenditure on different farming inputs under CNF and non-CNF crops are presented in Table 2.4 and Figure 2.5. As observed above, the expenditures on PNPIs, are significantly less under CNF vis-à-vis non-CNF. The expenditure towards PNPI of Paddy is 40 per cent less under CNF compared to non-CNF. The expenditure on other major items, especially on human labour and machine labour are more or less the same under CNF and non-CNF. There are marginal variations.

Table 2.4: Crop wise composition paid-out cost under CNF and non-CNF and their differences in Rabi 2023-24

Crop ➜	Paddy				Groundnut			
Indicator /Units ➜	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between CNF & non-CNF	
Input ↓/Farming type ➜	CNF	non-CNF	₹/ ha.	%	CNF	non-CNF	₹/ ha.	%
1	2	3	4	5	6	7	8	9
Seed	2,868	2,457	412	17	24,973	21,482	3,491	16
FYM	2,494	3,407	-913	-27	1,903	1,662	242	15
PNPIs	6,577	13,333	-6,756	-51	11,455	25,795	-14,340	-56
Human Labour	11,039	9,210	1,829	20	16,482	16,059	423	3
Bullock labour	1,265	2,125	-860	-40	2,352	1,663	689	41
Machine Labour	10,646	10,233	413	4	22,099	22,862	-763	-3
Others	1,822	1,961	-139	-7	4,630	4,875	-244	-5
Total	36,712	42,726	-6,014	-14	83,895	94,398	-10,503	-11

Table 2.4: (Cont.)

Crop ➜	Bengal gram				Maize			
Indicator/Units ➜	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between CNF & non-CNF	
Input ↓ / Farming type ➜	CNF	non-CNF	₹/ha.	%	CNF	non-CNF	₹/ ha.	%
1	10	11	12	13	14	15	16	17
Seed	7,593	8,076	-483	-6	7,303	6,122	1,180	19.3
FYM	4,075	1,361	2,714	199.3	-	479	-479	-100.0
PNPIs	7,933	18,717	-10,784	-57.6	5,702	22,816	-17,114	-75.0
Human Labour	8,916	9,229	-313	-3.4	12,771	15,704	-2,933	-18.7
Bullock labour	101	133	-32	-24.1	1,919	1,748	171	9.8

Crop ➜	Bengal gram				Maize			
Indicator/Units ➜	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between CNF & non-CNF	
Input ↓ / Farming type ➜	CNF	non-CNF	₹/ha.	%	CNF	non-CNF	₹/ ha.	%
1	10	11	12	13	14	15	16	17
Machine Labour	17,184	16,703	481	2.9	14,214	13,983	231	1.7
Others	878	335	543	162.3	4,423	3,636	786	21.6
Total	46,680	54,555	-7,875	-14.4	46,331	64,488	-18,157	-28.2

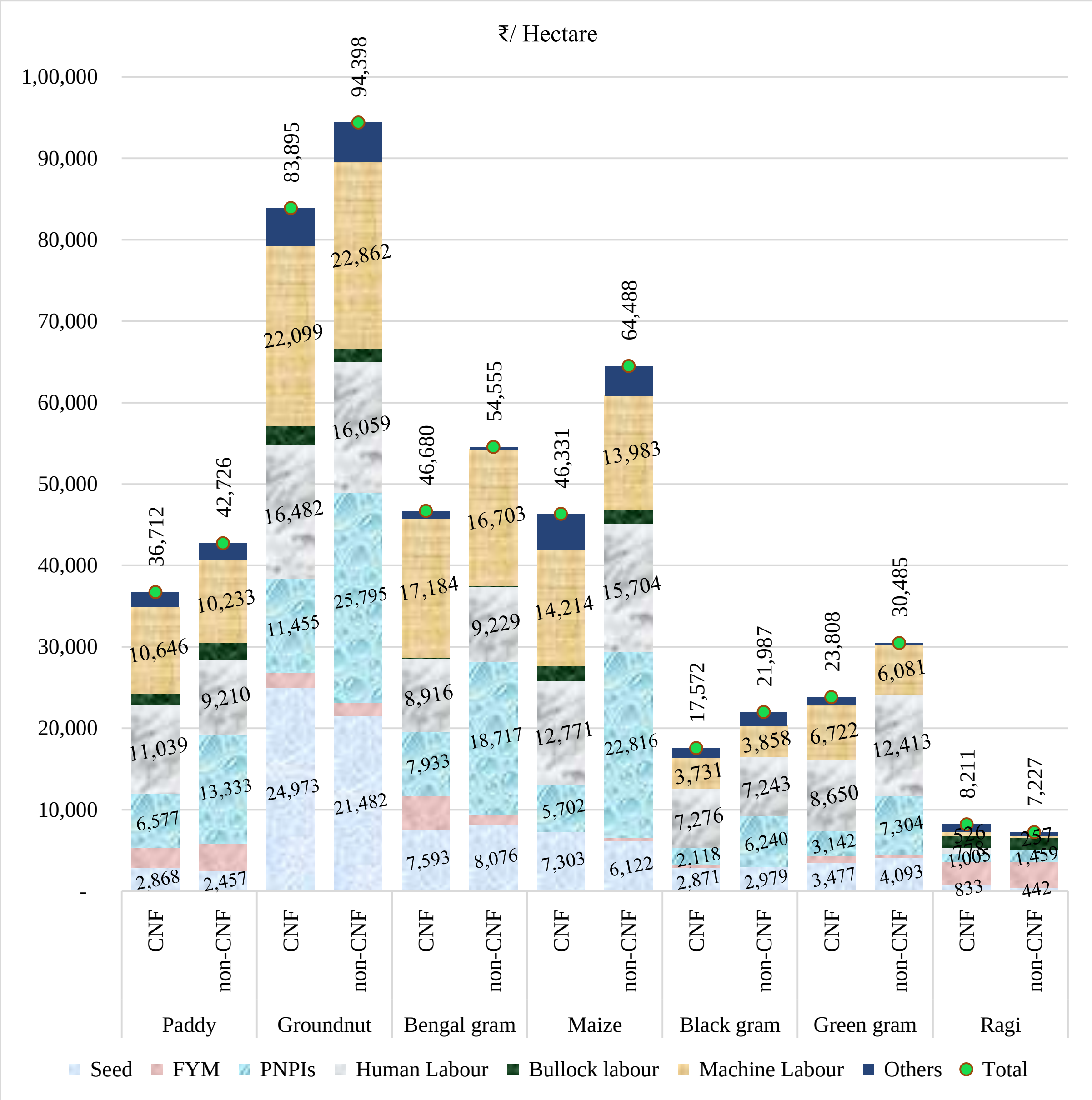
Table 2.4: (Cont.)

Crop ➜	Black gram				Green gram			
Indicator/Units ➜	₹/hectare		Difference between CNF & non-CNF		₹/hectare		Difference between CNF & non-CNF	
Input ↓ / Farming type ➜	CNF	non-CNF	₹/ha.	%	CNF	non-CNF	₹/ ha.	%
1	18	19	20	21	22	23	24	25
Seed	2,871	2,979	-108	-3.6	3,477	4,093	-616	-15.1
FYM	283	-	283	-	794	291	504	173.2
PNPIs	2,118	6,240	-4,123	-66.1	3,142	7,304	-4,162	-57.0
Human Labour	7,276	7,243	33	0.5	8,650	12,413	-3,763	-43.5
Bullock Labour	103	-	103	-	-	-	-	-
Machine Labour	3,731	3,858	-127	-3.3	6,722	6,081	641	10.5
Others	1,191	1,667	-476	-28.5	1,022	304	718	236.4
Total	17,572	21,987	-4,414	-20.1	23,808	30,485	-6,677	-21.9

Table 2.4: (Cont.)

Crop ➜	Ragi			
Indicator/Units ➜	₹/ hectare		Difference between CNF & non-CNF	
Input ↓ / Farming type ➜	CNF	non-CNF	₹/ ha.	%
1	26	27	28	29
Seed	833	442	391	88.4
FYM	2,749	3,157	-408	-12.9
PNPIs	1,005	1,459	-455	-31.1
Human Labour	778	-	778	-
Bullock Labour	1,422	1,511	-89	-5.9
Machine Labour	526	257	269	104.7
Others	898	400	498	124.5
Total	8,211	7,227	983	13.6

Figure 2.5: Crop wise composition paid-out cost under CNF and non-CNF and their differences in Rabi 2023-24



2.4. Crop yields

Out of seven crops considered in this report, the differences in yields of CNF and non-CNF are not statically different in five crops. In remain two crops, the CNF yields are higher in Groundnut and lower than that of non-CNF in Black gram. The crop yields of CNF are higher than that of non-CNF in all but one crop (Table 2.5 and Figure 2.6). Out of seven crops included in this report, the CNF yields are higher than that of non-CNF in four principal crops, viz., Paddy, Groundnut, Bengal gram and Maize, which are cultivated with considerable investment during the Rabi seas. On the other hand, the CNF yields are lower than that of non-CNF in three crops, viz., Black gram, Green gram and Ragi, which are cultivated on the fields after harvesting the Kharif Paddy, on the residual nutrients in the soil, with minimum investment. This indicates some presence of residual nutrients in non-CNF fields. In the previous surveys also, it was found that CNF crops' yields were either equal or higher than that of non-CNF in almost all crops, with one or two exceptions. The same is case now also.

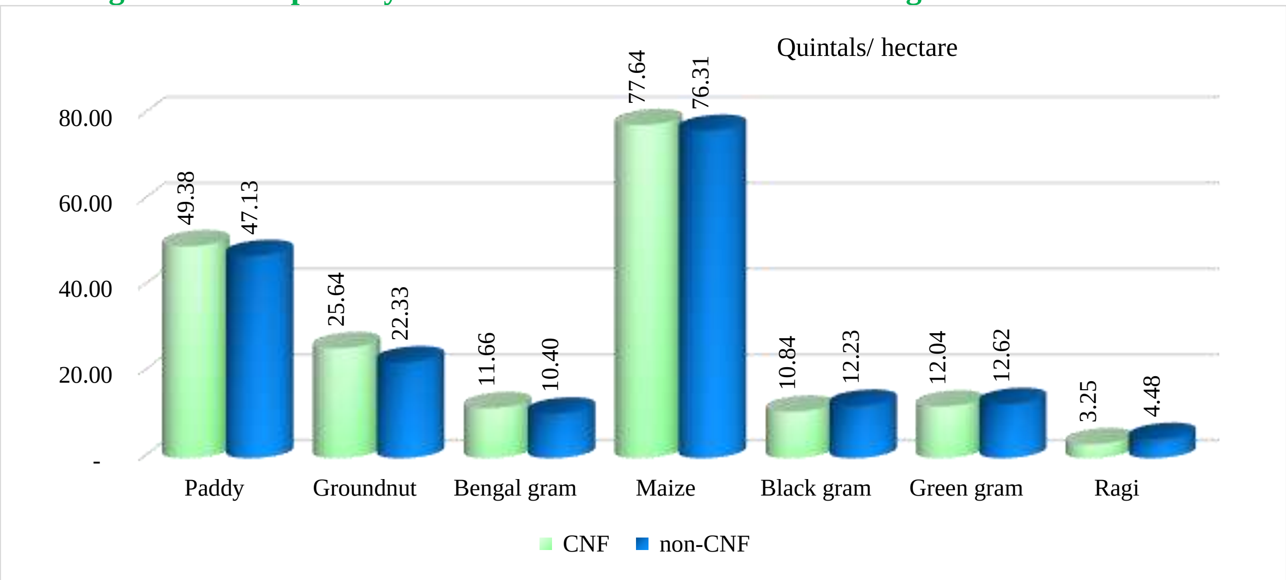
Table 2.5: Crop wise yields under CNF and non-CNF and their difference during Rabi 2023-24

Crop	quintals/hectare		Difference between CNF & non-CNF		Significant
	CNF	non-CNF	quintals/ha	in %	
Paddy	49.38	47.13	2.26	4.8	ns
Groundnut	25.64	22.33	3.31	14.8	**
Bengal gram	11.66	10.40	1.25	12.0	ns
Maize	77.64	76.31	1.33	1.7	ns
Black gram	10.84	12.23	-1.40	-11.4	**
Green gram	12.04	12.62	-0.58	-4.6	ns
Ragi	3.25	4.48	-1.22	-27.4	ns

**Significant at 1%; *Significant at 5%; ns= Not significant

Source: IDSAP Field Survey, 2023-24

Figure 2.6: Crop wise yields under CNF and non-CNF during Rabi 2023-24



2.5. Output prices

The prices received by the farmers, for their CNF output, are critical for the expansion of CNF in the state. Though CNF proved to be profitable, even without any special prices, the farmers want higher prices for their CNF output. The farmers are of the opinion that their CNF output is quality output, and, hence higher prices can be expected for the same. At the same time some of the consumers are also showing some interest in CNF output and are willing to pay higher prices. Various promotional activities of RySS, such as organization of weekly Shandies, arranging separate shops/ space in the Rythu Bazars and market places, tie up with Tirupati Tirumala Devasthanam (TTD), etc., not only provide additional market channels, but also a lot of awareness about CNF output. However, all these efforts are in the initial stages and in a small scale vis-à-vis the challenges of agriculture output marketing in the state and country. Crop wise average prices obtained by CNF and non-CNF farmers and their differences are presented in Table 2.6 and Figure 2.7. Out of seven crops covered, CNF output fetched higher prices in four crops and non-CNF output received higher prices in three crops. However, the differences in the prices of CNF and non-CNF output are statistically significant in only two crops, viz., Paddy and Black gram. In these two crops CNF output obtained higher price in Paddy and lower price in Black gram.

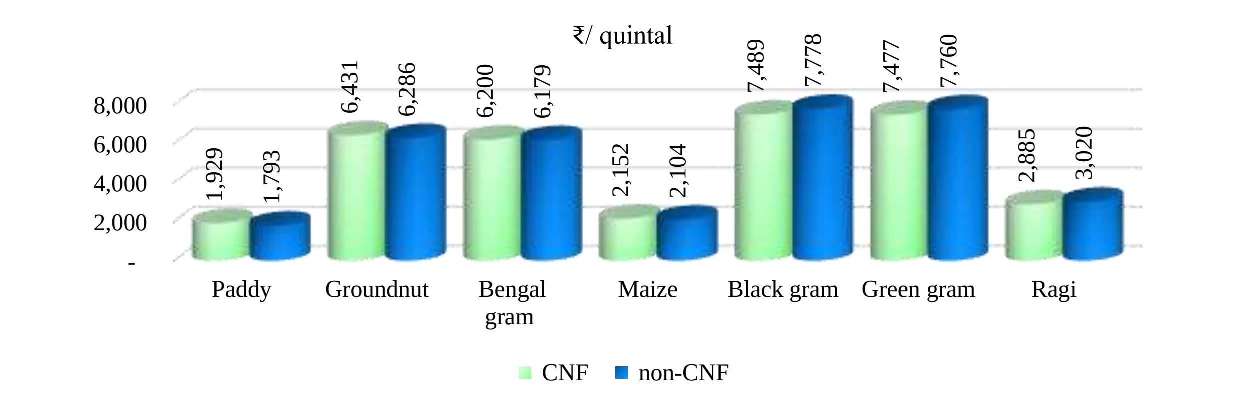
Table 2.6: Prices obtained for CNF and non-CNF crops and their difference during Rabi 2023-24

Crop	₹/quintal		Difference between CNF & non-CNF		Significant
	CNF	non-CNF	₹/ quintal	in %	
Paddy	1,929	1,793	135	7.6	*
Groundnut	6,431	6,286	145	2.3	ns
Bengal gram	6,200	6,179	21	0.3	ns
Maize	2,152	2,104	48	2.3	ns
Black gram	7,489	7,778	-289	-3.7	**
Green gram	7,477	7,760	-284	-3.7	ns
Ragi	2,885	3,020	-135	-4.5	ns

**Significant at 1%; *Significant at 5%; ns= Not significant

Source: IDSAP Field Survey, 2023-24

Figure 2.7: Prices obtained for CNF and non-CNF crops during Rabi 2023-24



2.6. Gross value of crop output

The gross value of output is obtained by multiplying the (CCE) yield with price and adding the value of by-product of the crop. Both the quantity and quality of yield and price obtained to the product play a vital role in determining the gross value of output. CNF farmers got more gross values than non-CNF farmers in four out of seven crops (Table 2.7 and Figure 2.8). In these four crops, the CNF farmers got higher gross value in the range of ₹6,084 per hectare in Maize to ₹21,775 per hectare in Groundnut. In relative terms, the CNF farmers got higher gross value in the range of 3.8 percent in Maize to 13.9 percent in Groundnut. On the other hand, the CNF farmers realized lower gross value in three crops, compared to non-CNF farmers, in the range of ₹3,430 per hectare in Ragi to ₹13,544 in Black gram. But in relative terms they obtained less gross value of output in the range of 8.2 percent in Green gram to 25.4 percent in Ragi. On average the CNF farmers obtained ₹4,607 per hectare or 4.8 percent higher gross value of output. Compared to previous Kharif season values, this margin is quite low. The possible reason is that in Rabi season, the non-CNF farmers, normally, invest more than enough and obtain higher crop output.[18]

Table 2.7: Crop wise gross values of CNF and non-CNF output and their difference during Rabi 2023-24

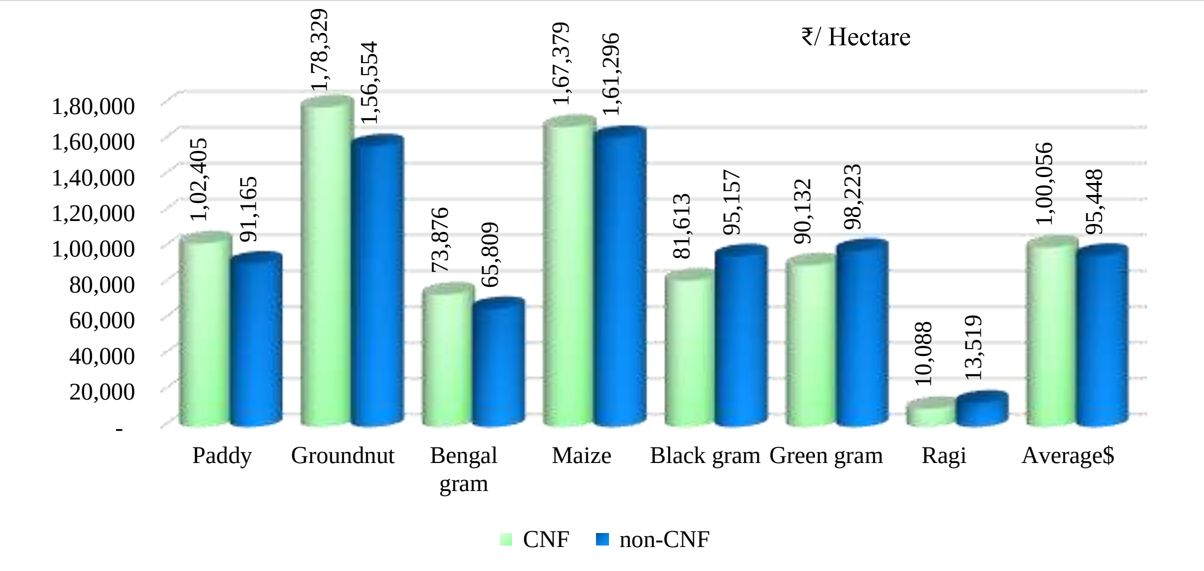
Crop	₹/Ha.		Difference between CNF & non-CNF	
	CNF	non-CNF	₹/Ha.	in %
Paddy	1,02,405	91,165	11,240	12.3
Groundnut	1,78,329	1,56,554	21,775	13.9
Bengal gram	73,876	65,809	8,068	12.3
Maize	1,67,379	1,61,296	6,084	3.8

[18] There are also other favourable natural factors like clear sky/ sunshine, controlled/ stable soil moisture conditions, fewer pest attacks, etc., resulting in higher crop production, especially in Paddy and Groundnut, the top two crops in the state.

Crop	₹/Ha.		Difference between CNF & non-CNF	
	CNF	non-CNF	₹/Ha.	in %
Black gram	81,613	95,157	-13,544	-14.2
Green gram	90,132	98,223	-8,092	-8.2
Ragi	10,088	13,519	-3,430	-25.4
Average$	1,00,056	95,448	4,607	4.8

$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP

Figure 2.8: Crop wise gross values of CNF and non-CNF output during Rabi 2023-24



$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP

2.7. Net value of crop output

The net value of crop output is derived by subtracting paid-out costs from gross value of output. As can be seen above, the CNF framers have less paid-out costs vis-à-vis non-CNF farmers for all, but crops. As a result, the CNF framers would get relatively higher net value of crop out vis-à-vis non-CNF farmers, due to the savings in their paid-out costs[19]. Crop wise net value of CNF and non-CNF output and their difference, during the study period are shown in Table 2.8 and Figure 2.9. Out of seven crops, the CNF farmers obtained higher net value of output in four crops in the range of ₹15,942 per hectare in Bengal gram to ₹32,277 per hectare in Groundnut. In relative terms, they obtained 25 percent to 141.7 percent of higher net value over non-CNF farmers in those four crops, viz., Paddy, Groundnut, Bengal gram and Maize.

[19] The savings obtained in the paid-out cost proved to be a critical factor in enhancing profitability during normal conditions and reducing the losses during the challenging conditions.

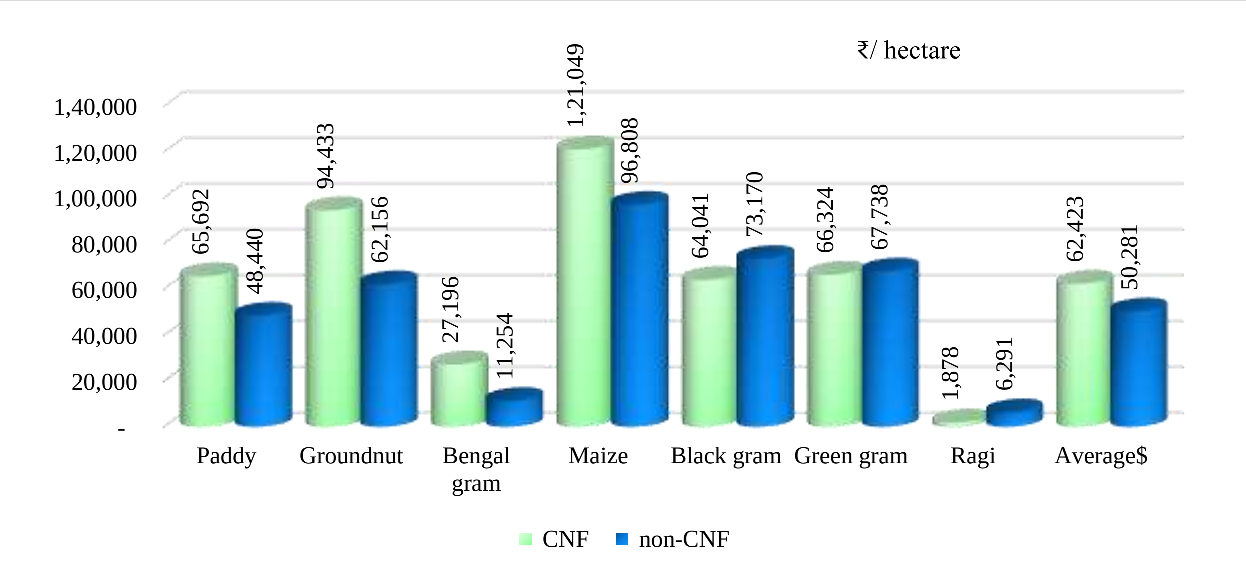
On the other hand, the CNF farmers obtained lower net value of output compared to that of non-CNF farmers in in three crops, viz., Black gram, Green gram and Ragi; in the range of ₹1,414 per hectare in Green gram to ₹9,129 per hectare in Black gram. On an average the CNF farmers obtained ₹12,142 per hectare or 24.1 percent of higher net value of crop output compared to that of non-CNF farmers (Table 2.8).

Table 2.8: Crop wise net values of CNF and non-CNF output and their difference during Rabi 2023-24

Crop	₹/ hectare		Difference between CNF & non-CNF	
	CNF	non-CNF	₹/ha	in %
Paddy	65,692	48,440	17,252	35.6
Groundnut	94,433	62,156	32,277	51.9
Bengal gram	27,196	11,254	15,942	141.7
Maize	1,21,049	96,808	24,241	25.0
Black gram	64,041	73,170	-9,129	-12.5
Green gram	66,324	67,738	-1,414	-2.1
Ragi	1,878	6,291	-4,414	-70.2
Average$	62,423	50,281	12,142	24.1

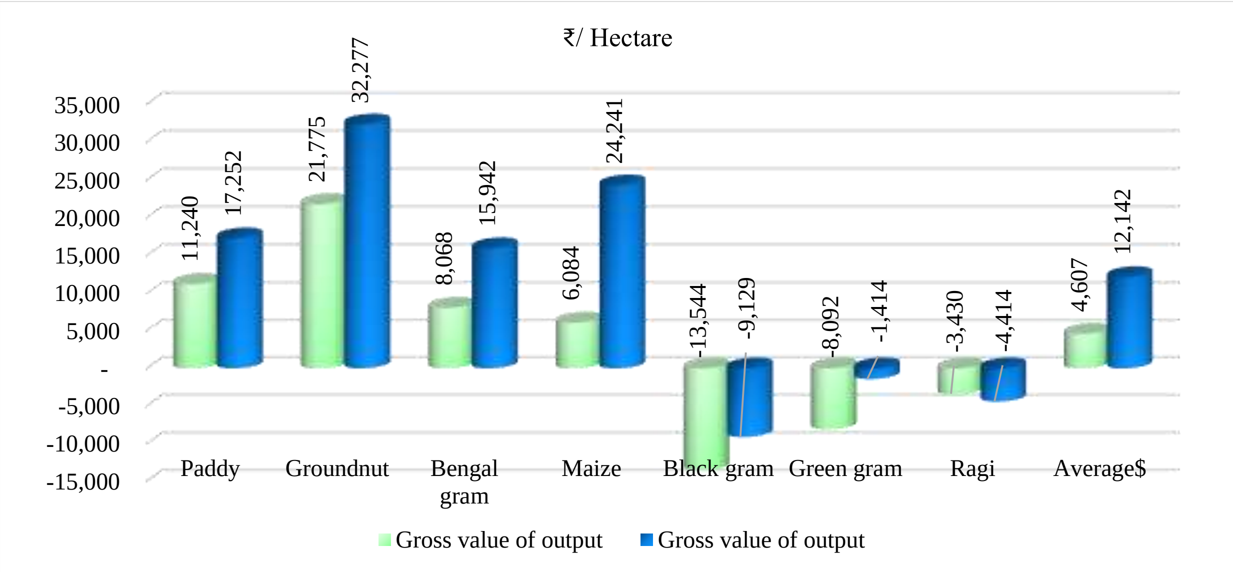
$ *Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP*

Figure 2.9: Crop wise net values of CNF and non-CNF output during Rabi 2023-24



It may be noted that reduction in the cost of cultivation is the major initial economic benefit, the farmers would get under the CNF. As mentioned above the savings obtained in the cost of cultivation (paid-out costs) help the farmers in improving their net value of output during the normal periods and in reducing their losses in the not-so-favorable periods. A companion of the differences in the gross and net value of CNF and non-CNF output (gross value of a CNF crop output minus gross value of that non-CNF output and net value of a CNF crop output minus net value of that non-CNF output) illustrates the point. The crop wise differences in gross and net value of CNF and non-CNF output are shown in Figure 2.10. It is interesting to see when the gross value of CNF output is higher than that of non-CNF, the difference in net value would be even higher than that of the difference in gross value, due to savings in the paid-out costs. If the gross value of CNF crop output is less than that of non-CNF, the difference in net value, usually, would be less than that of gross value of output. In the present case, in Black gram and Green gram, the difference in net value is less than that of gross value. Only in Ragi, in which CNF farmers incurred a little more paid-out cost[20], they got even lower net value of output compared to that non-CNF farmers. On average the CNF farmers got higher gross and net value of output of ₹4,607 and ₹12,142 respectively, owing to considerable savings in the paid-out costs.

Figure 2.10: Crop wise differences in gross and net value of CNF and non-CNF output in Rabi 2023-24



2.8. Conclusions

The analysis in this chapter provides yet another set of evidence about the effectiveness of CNF in improving the economic conditions of farmers and farming in the state. As in the past, the impact of CNF can be seen in two ways, i.e., through reduction in cost of cultivation and enhancing the crop yields and gross value of output. Because of these two factors, the CNF

[20] This issue was discussed in some of earlier reports also. That in Ragi, which is predominantly cultivated by the tribal farmers, very little agrochemicals are used under non-CNF.

farmers are able to obtain about 24.1 percent higher average net value vis-à-vis non-CNF farmers.

In this season, though CNF has performed well in four major crops, it could not so in three crops. Interesting all these crops are usually cultivated on the Kharif Paddy fields, using available residual moisture and nutrients. This appeared to be a special issue, RySS may investigate further. Or it may be result of annual fluctuations occurring in different crops, seasons and conditions owing to various weather and other factures.

Chapter 3

Chapter 3: Present Scenario and Future Prospects of Production Efficiency of Major Crop across Agroclimatic Zones and Farmer Categories Under CNF

3.1. Introduction

The costs and returns of significant crops cultivated during the 2023-24 rabi season provide a means for comparing the performance of CNF and non-CNF systems. The crops considered for this analysis include Paddy, Groundnut, Maize, Bengal gram, and Black gram. The primary aim is to understand the factors influencing the net value of output (profit) by analyzing the roles of paid-out costs, yields, and output prices. The net value of output is measured to assess production efficiency.

The net output value is calculated by subtracting paid-out costs from the gross production value. The gross value is derived by multiplying the area under each crop by its yield and the price received by farmers. Paid-out costs include all production-related expenses, such as inputs, hired labour, and operational costs. This analysis compares the performance of CNF and non-CNF systems across key profit determinants.

In this chapter, we are addressing the following specific issues with a focus on the comparison of the two systems with the following points:

1. Assess the relative contributions of paid-out costs, yield, and output prices to profitability.
2. Investigate which agroclimatic zones and farmer categories have achieved higher profits and how the components-paid out costs, yield and output prices shape those profits.
3. Analyse the efficiency of input utilization and whether output prices are being realized at optimal levels under CNF system.

3.2. Research Questions

The pertinent research questions, designed to guide the investigation into the costs and returns under CNF and non-CNF systems and seeking answers, are discussed below:

i. Comparison of Profits Across Agroclimatic Zones for CNF and non-CNF

ii. To identify which agroclimatic zones have generated higher profits under CNF compared to non-CNF and to determine how input costs, yield, and output prices contribute to these profit differences.

iii. Profit Comparison Across Farmer Categories for CNF and non-CNF

iv. Which farmer categories have achieved greater profits under CNF than non-CNF for each crop, and what roles do input costs, yield, and output prices play in these profit disparities?

v. Cost Efficiency and Profitability for CNF and non-CNF

vi. Which zones and farmer categories have attained profits at lower costs under CNF compared to non-CNF, and how does this relate to input efficiency and price realization?

vii. Efficiency in Input Utilization for CNF and non-CNF

viii. Which zones and farmer categories have utilized inputs more effectively to maximize yields under CNF than non-CNF and Price Realization Relative to Input Costs?

ix. Which zones and farmer categories have achieved higher output prices relative to input costs under CNF compared to non-CNF?

These questions provide a framework for understanding the factors contributing to profitability, emphasizing CNF versus non-CNF systems.

3.3. Methodology

The methodology integrates descriptive analysis, elasticity analysis, and resource use efficiency analysis to provide a comprehensive evaluation of CNF relative to non-CNF. The analysis uses a two-tier approach, wherein:

Elasticity Analysis quantifies how key variables—paid-out costs, yield, and output prices—contribute to profitability. Descriptive and Efficiency Analyses address broader questions about cost efficiency, input utilization, and price realization. By integrating these three complementary analyses, this methodology provides a holistic view of how different factors shape the profitability and resource efficiency of CNF system, offering a comparison between CNF systems and non-CNF systems.

3.3.1. Elasticity Analysis of Profit Concerning Yield, Prices, and Paid-out Costs

Elasticity analysis quantifies profit's responsiveness to changes in key factors: yield, output prices, and paid-out costs. This approach is essential for understanding how sensitive profits are to variations in these variables under CNF and non-CNF systems.

The elasticity formula is as follows.

Formula:

Elasticity of Profit concerning X = (% Change in Profit for CNF over non-CNF) / (% Change in X in CNF over Non-CNF)

Where X refers to yield, prices, or input costs, the profit elasticity is calculated for each agroclimatic zone and farmer category to pinpoint the relationship between these factors and profitability.

The elasticity analysis proceeds with the following steps.

i. ***Elasticity of Profit with Respect to Yield: Measures how changes in yield influence profit.***
ii. ***Elasticity of Profit with Respect to Price: Measures how changes in output prices affect profit.***
iii. ***Elasticity of Profit with Respect to Paid-out Costs: Measures the impact of changes in paid-out costs on profit.***

This degree of analysis enables us to understand how each factor contributes to profitability under both farming systems.

3.3.2. Supplementing Descriptive Analysis with Elasticity Analysis

While descriptive analysis provides insights into current yield trends, prices, and input costs, it does not quantify how these changes directly influence profit. Elasticity analysis enhances this understanding by quantifying the impact of these factors on profit, thus adding depth to the descriptive analysis.

For example, descriptive analysis may show that CNF farmers have higher yields than their non-CNF counterparts. However, elasticity analysis helps assess whether this higher yield is the primary driver of profit or if other factors, such as lower input costs or higher prices, are more significant in driving profitability. This clarifies the relationship between yield, costs, expenses, and profits.

3.3.3. Resource Use Efficiency and Profitability Analysis

In addition to the elasticity analysis, the study examines the efficiency with which inputs are utilised in CNF system and compares it to that of non-CNF system. By analysing resource use efficiency, we aim to understand how well inputs are used to maximise profit, yield, and output prices at lower costs.

Key steps include

i. ***Efficiency of Input Use: Measures how effectively inputs are utilized to achieve higher yields with fewer resources for CNF over non-CNF.***
ii. ***Cost Efficiency: Can CNF farmers achieve higher profitability with lower input costs, compared to non-CNF farmers.***
iii. ***Price Realization: Examines whether CNF farmers can secure better output prices relative to their input costs.***

These analyses clarify the potential for efficiency gains in CNF system and strategies for improving profitability.

3.3.4. Integrated Analysis of Profit Dynamics

The integration of elasticity analysis, descriptive analysis, and resource use efficiency analysis provides a comprehensive methodology for evaluating the profitability of CNF versus non-CNF systems. This two-tier approach—comprising quantitative elasticity analysis and qualitative resource use efficiency analysis—allows us to assess both profit drivers and farming practices' efficiency.

Combining these three streams of analysis, we can identify areas where CNF farmers can improve profitability, whether by enhancing yield, improving input efficiency, or realising better output prices. This integrated methodology not only provides a robust framework for understanding the dynamics of CNF and non-CNF farming systems but also suggests actionable policy recommendations for increasing profits in sustainable farming system.

The comprehensive analysis presented in this chapter aims to offer a deeper understanding of the economic dynamics of CNF and non-CNF systems. Integrating descriptive, elasticity, and efficiency analyses provides valuable insights into the factors influencing profitability across different agroclimatic zones and farmer categories. By assessing resource efficiency, price realization, and profit sensitivity to key variables, the chapter identifies practical pathways for enhancing the profitability of CNF. These insights, coupled with policy implications, can guide future efforts to promote sustainable farming practices that improve farmer profitability and contribute to agriculture's long-term viability in diverse agroclimatic regions.

Analysis of elasticities quantifies the relationship between yield, prices, and input costs, providing clear policy direction. The descriptive analysis helps identify current trends in profit dynamics. Efficiency analysis pinpoints resource utilization practices that can boost profits in Natural Farming. The integrated methodology helps outline concrete strategies for improving profitability in sustainable farming systems.

3.4. Analysis

The Appendix Tables of Chapter 3 present details on the costs and returns of crops for CNF and non-CNF in different agroclimatic zones and farmer categories.

3.4.1. Paddy Farming

Paddy is a staple crop grown across six agroclimatic zones in Andhra Pradesh. The current analysis, however, focuses on three specific zones: HAT (tribal), Godavari, and Southern, which differ significantly in terms of resource availability and farming practices. Godavari is a resource-rich zone, the South is a resource-poor zone, and HAT represents a tribal zone. The study compares CNF and non-CNF based on key factors, including profit, yield, prices, and paid-out costs.

i. Key Findings from Zonal Analysis

(a) In the HAT zone, CNF farmers have faced challenges in achieving higher prices for their crop output compared to non-CNF farmers, suggesting limited market access and a lack of support for CNF products despite their chemical-free nature. However, CNF farmers have achieved higher yields, which is expected due to using biological inputs that enhance soil health. Although paid-out costs for CNF farmers are higher than those for non-CNF farmers, the increased yields have offset these additional costs, resulting in higher profits. The higher paid-out costs can be attributed to the higher price of biological inputs, compounded by the lower availability of these inputs in tribal areas, where they are often scarce or overpriced.

Elasticity analysis reveals some key dynamics in profit generation. The elasticity of profit is detrimental; the elasticity of output prices in relation to yield and input costs is both damaging and harmful. Specifically, a 1% increase in output prices results in a 9.29% reduction in profits, indicating that raising prices is not a viable strategy for increasing profits in this scenario. Instead, rising yields and effective input cost management emerge as more feasible strategies. According to the elasticity values, a 1% increase in yield results in a modest 0.78% increase in profit, indicating that the response of profits to yield improvement is moderate. However, yield improvement can only be achieved through increased input costs, which are already relatively high. Therefore, increasing input costs further is not a viable strategy to boost profits. The most feasible option for increasing profit is to improve yields, which can only be achieved by adopting CNF practices in their entirety.

Resource use analysis corroborates the findings of the elasticity analysis, showing that CNF farmers utilise input resources efficiently to both increase profits and achieve higher yields compared to their non-CNF counterparts. However, the study also indicates that resources are inefficiently used when realising higher prices for crop outputs. This underscores the importance of providing CNF farmers with better market access to secure higher prices for their produce. In conclusion, the primary strategy to enhance profits in the HAT zone is not to increase prices further but to improve market access for CNF products while simultaneously adopting CNF practices to increase yields further (Tables 3.1 and 3.2)

(b) In the Godavari zone, CNF farmers experienced lower yields than their non-CNF counterparts, contrary to expectations. Despite this, CNF farmers could secure higher prices for their produce. This price advantage is likely due to the developed market systems and increasing consumer preference for chemical-free products. The reduced paid-out costs for CNF farmers compared to non-CNF farmers further suggest a more efficient use of inputs. However, the lower yields in CNF farming in this zone indicate inefficiencies in using biological inputs, highlighting areas where improvements can be made.

The elasticity analysis reveals that changes in output prices have a more significant impact on profit than changes in yield or input costs. The one per cent price increase results in a substantial rise in profits, which helps boost the earnings of CNF farmers. On the other hand, the elasticity to yield is negative, indicating that increasing yield may not significantly improve profitability without addressing the underlying inefficiencies in input use.

From the resource use efficiency perspective, CNF farmers in Godavari are utilising resources more efficiently to generate profits, yields, and output prices at lower costs than their non-CNF counterparts. The efficiency in input use is evident in the reduced paid-out costs, which contribute to higher profit margins despite the lower yields. However, any further increase in output prices could become counterproductive, as current prices are already relatively high. Additionally, reducing input use further is not a viable option, as input costs have already been reduced significantly.

Thus, improving yields through ultimately adopting CNF practices is the most viable strategy for enhancing profitability in this zone. Given the existing inefficiencies in biological input use, CNF farmers should focus on improving yield performance through better resource management and full adoption of natural farming practices. This approach can potentially enhance profitability without further increases in output prices or reductions in input use (Tables 3.1 and 3.2).

(c). In the Southern zone, CNF farmers have achieved higher yields, higher prices, and lower input costs compared to their non-CNF counterparts, which collectively contributed to significantly higher profits. Farmers in this zone have demonstrated an efficient use of biological inputs, resulting in improved yields and lower overall costs. The well-established market systems in the Southern zone likely facilitated the higher prices received for CNF produce.

The elasticity analysis reveals that the elasticity to yield (137.82) is exceptionally high, indicating that even minor improvements in yield can lead to substantial increases in profits. Similarly, the price elasticity (83.69) shows that price increases have a significant positive impact on profits. However, the elasticity to input costs (-6.44) suggests that controlling input costs is crucial for maximising profits in this zone, as any increase in these costs would reduce the benefits gained from higher yields and prices.

Given that CNF farmers are already realising higher prices compared to their non-CNF counterparts, further increases in output prices do not appear to be a feasible option for boosting profits in this zone. Additionally, additional reductions in input costs are not a viable strategy, as CNF farmers have already achieved significant cost savings.

The most promising strategy to enhance profitability in this zone is to improve yields further. Increasing yields through the complete adoption of CNF practices presents the best opportunity for further profit growth, as resources are already being utilised efficiently to generate profits, yields, and prices at lower costs.

The zonal analysis has provided valuable insights into how CNF practices can be leveraged to enhance profitability, yields, and output prices in various agro-climatic zones. While there are challenges, such as market access issues in the HAT zone and inefficiencies in input use in the Godavari zone, adopting CNF practices in their entirety remains a key strategy to overcome these barriers. The Southern zone serves as an example of the positive outcomes that can result from improved yield performance, lower input costs, and strong market systems. CNF farmers can unlock their full potential for increased profitability across all zones by focusing on yield improvement. Effective policy interventions should focus on improving market access, enhancing input efficiency, and promoting the complete adoption of CNF practices to maximise agricultural sustainability and profitability (Tables 3.1 and 3.2).

ii. Key Findings from Farmer Categories

The analysis was conducted across three categories-marginal, small and other farmers (including medium and large farmers). The results revealed notable variations in the performance of CNF farmers compared to non-CNF farmers across these categories.

(a). Marginal Farmers

Among all farmer categories, marginal CNF farmers showed the highest profit margins over their non-CNF counterparts, despite experiencing lower crop yields. Higher output prices and lower input costs are the primary contributors to this higher profit. This suggests that while marginal CNF farmers benefit from reduced input costs, they may not be utilising inputs optimally, which could explain their lower yields relative to non-CNF farmers.

The elasticity analysis offers further insights into the dynamics of profitability. For marginal CNF farmers, a 1% increase in yield results in a 14.77% decrease in profit relative to non-CNF farmers, while a 1% increase in input costs leads to a 1.52% reduction in profit. However, a 1% increase in output prices results in a 6.67% increase in profit. This highlights that marginal CNF farmers are susceptible to changes in output prices, with price increases significantly boosting profits. However, the lower yield and reduced input use indicate inefficiencies in input utilisation within the CNF system for these farmers.

The resource efficiency analysis further confirms that CNF farmers, compared to their non-CNF counterparts, have achieved higher profits, yields, and output prices at lower costs. However, the only feasible way to further enhance earnings in this category is through increased output prices. This may be counterproductive in the long run, as higher prices could reduce consumer demand for CNF products. Reducing input costs, while beneficial for lowering overall expenses, hampers yield. Thus, the most viable solution for marginal CNF farmers is to focus on increasing yield by optimising biological inputs and fully adopting CNF practices to improve soil health, leading to better crop productivity (Tables 3.1 and 3.2).

(b). Small Farmers

Small farmers in the CNF system appear to be in a better position compared to their non-CNF counterparts, showing improved profits driven by both yield improvements and cost reductions. In this category, the relationship between yield and profit is more balanced, suggesting that CNF practices offer advantages not only in price realisation but also in reducing input costs.

However, the elasticity analysis for small farmers shows that profit elasticities to yield, output prices, and input costs are relatively inelastic, with elasticity values less than one. This indicates that changes in these factors have a less than proportional effect on profits. Moreover, small farmers in the CNF system have achieved higher profits, yields, and output prices at higher resource costs than non-CNF farmers. This suggests that small CNF farmers may not use resources as efficiently as possible.

Enhancing the efficiency of input utilisation among small farmers is essential to improving profitability and yield. This can be achieved by adopting CNF practices to improve soil health and boost crop productivity, thus driving more efficient resource use and ultimately increasing profits.

The analysis suggests that both marginal and small farmers have the potential for significant profit improvements through better adoption and optimisation of CNF practices. However, marginal farmers face challenges in yield improvement due to inefficiencies in input utilisation, while small farmers need to enhance resource use efficiency.

In both categories, improving yield through better biological input management and adopting CNF practices holistically offers the most promising path to profitability. Additionally, while price realisation is essential, the focus should be on improving market access and resource use efficiency rather than relying solely on price increases or further reductions in input costs. These strategies, tailored to each farmer category's unique challenges and opportunities, will help achieve sustainable growth in yield and profit (Tables 3.1 and 3.2).

Table 3.1: Role of yield, prices and paid-out costs in profit-making for Paddy in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Increase in Profit of CNF over non-CNF (%) (2)	Increase in Yield of CNF over non-CNF (%) (3)	Increase in Output of CNF over non-CNF (%) (4)	Increase in Paid-out cost of CNF over non-CNF (%) (5)	Elasticities of profit concerning		
					Yield of Crop (2)/ (3)	Price of crop output (2)/ (4)	Costs of inputs (2)/ (5)
Zones							
HAT	21.83	28.10	-2.35	19.34	0.78	-9.29	1.13
Godavari	61.61	-2.01	6.64	-36.56	-30.65	9.28	-1.69
Southern	266.12	1.93	3.18	-41.35	137.82	83.69	-6.44
Farmer Categories							
Marginal	47.99	-3.25	7.20	-31.53	-14.77	6.67	-1.52
Small	5.08	8.32	9.53	52.04	0.61	0.53	0.10
Others	20.34	49.00	3.67	160.81	0.42	5.54	0.13

Source: Field Survey of IDSAP, Rabi 2023-24

Table 3.2: Cost efficiency of profitability, efficiencies in input utilisation and price realization relative to input costs for Paddy in Rabi for different agroclimatic zones and farmer categories in CNF and Non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Paddy Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	non-CNF (3)	CNF (4)	non-CNF (5)	CNF (6)	non-CNF (7)
Zones						
HAT	3.15	3.09	2.31	2.15	10.25	12.52
Godavari	1.98	0.78	1.38	0.89	4.53	2.69
Southern	1.07	0.17	0.88	0.51	3.93	2.23
Farmer Categories						
Marginal	1.76	0.81	1.33	0.94	5.09	3.25
Small	1.89	2.74	1.42	1.99	5.54	7.69
Others	2.00	4.33	1.43	2.51	6.27	15.78

Source: Field Survey of IDSAP, Rabi 2023-24
Note: Ratio of yields to input costs in multiplied by 1000 to adjust for decimal points and ratio of crop output price to input costs multiplied by 100 to adjust for decimal points.

3.4.2. Groundnut Farming

i. Zonal Analysis

Groundnut farming in Andhra Pradesh predominantly occurs in two zones: the **Southern Zone** and the **Scarce Rainfall Zone**. These zones exhibit distinct environmental challenges, with the Southern Zone experiencing comparatively stable rainfall. At the same time, the Scarce Rainfall Zone suffers from erratic weather patterns, including prolonged droughts, unpredictable rainfall, high temperatures, and pest infestations. Despite these differences, CNF farmers in the Scarce Rainfall Zone achieved higher profits than their counterparts in the Southern Zone. This suggests that Groundnut farming in the Scarce Rainfall Zone, particularly in the rabi season, can be relatively free from severe production risks.

In the Scarce Rainfall Zone, CNF farmers have been able to achieve higher profits compared to their non-CNF counterparts. This is attributed to higher yields, higher output prices, and reduced input costs. The elasticity analysis reveals that a 1% increase in yield leads to a 2.73% increase in profits, while a 1% increase in output prices results in a remarkable 45.04% increase in profits. Furthermore, a 1% increase in input use also results in a 23.38% increase in profits, showing a strong relationship between resource input and profitability. The efficiency in resource use by CNF farmers is higher than that of non-CNF farmers, indicating the effective utilization of inputs to achieve optimal outputs. For further profit enhancement, providing strong market support for CNF farmers and encouraging the full adoption of CNF practices to improve soil health are crucial (Tables 3.3 and 3.4).

In the Southern Zone, CNF farmers also experienced higher profits than their non-CNF counterparts, primarily due to favourable output prices and reduced input costs. However, in this zone, yields did not increase significantly. Elasticity analysis reveals that a 1% increase in output prices results in a 3.95% increase in profits. In comparison, a 1% increase in yields and input use led to significant reductions in profit, by 14.48% and 1.61%, respectively. This suggests that raising output prices is the most effective strategy for increasing profits in the Southern Zone, and this can only be achieved through stronger market linkages and support for CNF products. On the resource-use efficiency front, CNF farmers in the Southern Zone demonstrate higher input utilisation efficiency than their non-CNF counterparts, indicating that there is limited potential for further profit improvement through better resource use. Thus, the key focus for CNF farmers in this zone should be securing better market access and higher prices (Tables 3.3 and 3.4).

The analysis of Groundnut farming highlights the importance of market access, input management, and the adoption of CNF practices in enhancing farmers' profitability. While CNF farmers in both the Southern and Scarce Rainfall Zones are more efficient in resource use, the primary focus for increasing profits in the Southern Zone should be securing better prices through market linkages. In contrast, CNF farmers in the Scarce Rainfall Zone can still benefit from improvements in yield, but this requires increased adoption of CNF practices to improve soil health and optimize biological inputs. Ultimately, the key to further success for CNF farmers in both zones lies in better market access, effective resource use, and the complete adoption of CNF practices.

ii. Key Findings from Farmer Categories

The analysis focused on two categories of farmers: marginal and small farmers.

(a). Marginal Farmers: In the case of marginal farmers, CNF practices have led to significantly higher profits than their non-CNF counterparts. The primary contributors to these profits are higher crop yields and reduced input costs rather than higher crop output prices. The resource use efficiency analysis reveals that CNF farmers utilise resources more efficiently than non-CNF farmers, achieving higher profits, yields, and output prices with reduced input use. This suggests that reallocating resources further may not provide additional profit benefits. According to elasticity analysis, increasing yields is the most effective strategy to further enhance profits. Increasing output prices or input use would be less effective. Therefore, the most effective approach for marginal CNF farmers to increase profits is to fully adopt CNF practices that enhance soil health, resulting in higher yields (Tables 3.3 and 3.4).

(b). Small Farmers: Small farmers practicing CNF have achieved higher profits than their non-CNF counterparts, primarily through higher output prices and lower input costs. However, these farmers have lower yields compared to their non-CNF counterparts. The resource use efficiency analysis indicates that these farmers are already utilizing resources efficiently, which means there is little room for further improvement in profit by adjusting resource use. Elasticity analysis indicates that the most viable option for increasing profits is to increase output prices. Therefore, strong market support is crucial for CNF small farmers to secure higher prices for their produce, which will in turn enhance their profits further (Tables 3.3 and 3.4).

The adoption of CNF practices has proven to be beneficial for both marginal and small farmers in terms of achieving higher profits. However, the strategies for further improvement differ based on farmer categories. Marginal farmers must focus on yield improvements through better soil health and biological inputs. In contrast, small-scale farmers require improved market linkages and better price realization to enhance their profitability. Future policy interventions should focus on strengthening market systems for CNF products and promoting further adoption of CNF practices to enhance soil health and crop productivity.

Table 3.3: Role of yield, prices and paid-out costs in profit-making for Groundnut in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Increase in Profit of CNF over non-CNF (%) (2)	Increase in Yield of CNF over non-CNF (%) (3)	Increase in Output of CNF over non-CNF (%) (4)	Increase in Paid-out cost of CNF over non-CNF (%) (5)	Elasticities of profit with respect to		
					Yield of Crop (2)/ (3)	Price of crop output (2)/ (4)	Costs of inputs (2)/ (5)
Zones							
Southern	23.45	-1.62	5.93	-14.60	-14.48	3.95	-1.61
Scarce rainfall	54.95	20.11	1.22	-2.35	2.73	45.04	-23.38
Farmer Categories							
Marginal	45.46	17.32	-0.87	-12.72	2.62	-52.25	-3.57
Small	18.91	-0.91	2.45	-14.18	-20.78	7.72	-1.33
Others	194.08	32.48	8.49	-12.96	5.98	22.86	-14.98

Source: Field Survey of IDSAP, Rabi 2023-24

Table 3.4

Table 3.4: Cost efficiency of profitability, efficiencies in input utilisation and price realisation relative to input costs for Groundnut in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	Non-CNF (3)	CNF (4)	Non-CNF (5)	CNF (6)	Non-CNF (7)
Zones						
Southern	1.34	0.95	0.34	0.30	17.21	13.95
Scarce rainfall	0.85	0.53	0.26	0.21	12.38	8.09
Farmer Categories						
Marginal	1.15	0.69	0.31	0.23	14.87	10.13
Small	1.13	0.82	0.31	0.27	13.48	11.61

Agroclimatic Zones and farmer Categories (1)	Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	Non-CNF (3)	CNF (4)	Non-CNF (5)	CNF (6)	Non-CNF (7)
Others	1.10	0.32	0.30	0.20	15.67	5.78

Source: Field Survey of IDSAP, Rabi 2023-24
Note: Ratio of yields to input costs in multiplied by 1000 to adjust for decimal points and the ratio of crop output price to input cost is multiplied by 100 to adjust for decimal points.

3.4.3. Bengal Gram Farming

Bengal gram is primarily cultivated in the Krishna and Southern zones. The analysis of profit dynamics in these zones highlights key differences in performance between CNF and non-CNF farmers.

i. Zonal Analysis

(a). Krishna Zone: In the Krishna zone, CNF farmers have achieved higher profits compared to their non-CNF counterparts. This higher profit is attributed to increased crop yields and higher output prices, despite higher input costs. The resource efficiency analysis indicates that CNF farmers in this zone utilise resources more effectively to achieve higher profits, yields, and crop output prices at lower costs than non-CNF farmers. However, improving resource use efficiency further does not seem to offer additional profit benefits.

The elasticity analysis further emphasizes the significance of yield changes in driving profitability. A 1% increase in yield results in a notable 17.01% increase in profit for CNF farmers compared to non-CNF farmers. This highlights the critical importance of improving soil health through CNF practices to boost yields, which remains the most viable strategy for CNF farmers in this zone to further increase profits (Tables 3.5 and 3.6).

(b). Southern Zone: In the Southern zone, CNF farmers also outperformed their non-CNF counterparts in terms of profits. The increase in profits can be attributed to higher yields and higher output prices for CNF farmers, despite higher input costs. However, the resource use efficiency analysis suggests that CNF farmers are realizing profits, yields, and output prices at higher costs than non-CNF farmers.

Increasing resource use efficiency in this zone offers further potential for enhancing profits. The elasticity analysis indicates that a 1% increase in yield leads to a 67.68% increase in profit, while a 1% increase in output prices results in a 55.05% increase in profits. Interestingly, a 1% increase in input costs is associated with a 10.60% increase in profit, indicating a gap in the efficient use of inputs. This suggests that increasing investments in CNF practices for improving soil health could further boost yields, while strong market support to secure premium prices for CNF outputs could significantly enhance profit margins (Tables 3.5 and 3.6).

The analysis of Bengal gram farming in the Krishna and southern zones highlights the importance of adopting comprehensive CNF practices to enhance soil health and improve crop productivity. For CNF farmers, particularly in the southern zone, strong market support is crucial to securing better prices and maximising profits. By focusing on improving yields through efficient resource use and ensuring market access, CNF farmers can further enhance their profitability and continue to reap the benefits of sustainable farming practices.

ii. Farmer Categories Analysis

The profit potential of CNF practices is clearly demonstrated when comparing the outcomes of CNF and non-CNF systems, particularly across different farmer categories, such as marginal and small farmers. A key observation is that medium and large farmers have also benefited significantly from CNF practices, outperforming their non-CNF counterparts in profit. However, the most remarkable results come from marginal farmers, who have substantially profited under the CNF system.

(a). Marginal Farmers

Marginal CNF farmers have achieved a 326.16% higher profit than their non-CNF counterparts. This impressive gain stems primarily from higher yields and reduced input costs. However, despite the overall profit boost, these farmers have not experienced a proportional increase in yields under the CNF system when compared to non-CNF farming. This suggests that while input costs are efficiently controlled, there is still room for improvement in yield optimization for marginal farmers.

The analysis of resource-use efficiency indicates that marginal CNF farmers are already utilizing their available resources efficiently, as reflected in lower input costs while maintaining competitive yields and realising output prices. However, given this already efficient resource use, further profit improvement cannot be achieved by simply reallocating resources or reducing input costs further. Instead, the key to improving profits lies in increasing crop yields.

The elasticity analysis of profit with respect to yield, crop output prices, and input costs reinforces this conclusion. A significant yield increase is the most viable strategy for enhancing profits for marginal CNF farmers. By improving soil health and fully adopting all CNF practices, farmers can boost yields, which in turn will drive up profits. This suggests that continued focus on soil health improvement and fully adopting CNF practices will be essential for marginal farmers to maximize their profit potential (Tables 3.5 and 3.6).

(b). Small Farmers

Like their marginal counterparts, small farmers in the CNF system have also benefitted from higher yields and a considerable reduction in input costs compared to non-CNF farmers. Interestingly, despite receiving lower prices for their produce than non-CNF farmers, the lower input costs and higher yields have allowed small CNF farmers to achieve higher profits.

The resource-use efficiency of small CNF farmers has been comparable to that of non-CNF farmers, and further improvements in resource utilization alone will not increase profits.

The elasticity of profit for small farmers, with respect to yield, output prices, and input costs, indicates that the most promising route to enhance profits is through increased yields. Despite receiving lower prices, small farmers have the potential to achieve significantly higher profits through improvements in crop yield, highlighting the importance of adopting CNF practices that promote soil health and boost productivity (Tables 3.5 and 3.6).

In conclusion, while both marginal and small farmers under the CNF system have demonstrated significant profit potential compared to non-CNF farmers, each category faces different challenges and opportunities. Marginal farmers must improve yields through better resource management and soil health. In contrast, small farmers must focus on optimizing yield for improved profitability despite the lower output prices they may receive.

The potential for CNF to drive sustainable, profitable farming practices is clear, but success depends on tailored strategies for each farmer category. Supporting both groups with the necessary resources, knowledge, and market access will be crucial for realizing the full benefits of CNF farming.

Table 3.5: Role of yield, prices and paid-out costs in profit-making for Bengal gram in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Increase in Profit of CNF over non-CNF (%) (2)	Increase in Yield of CNF over non-CNF (%) (3)	Increase in Output of CNF over non-CNF (%) (4)	Increase in Paid-out cost of CNF over non-CNF (%) (5)	Elasticities of profit with respect to		
					Yield of Crop (2)/ (3)	Price of crop output (2)/ (4)	Costs of inputs (2)/ (5)
Zones							
Krishna	67.31	3.78	-0.71	-14.79	17.01	-94.00	-4.55
Scarce rainfall	201.48	2.97	3.66	19.00	67.68	55.05	10.60
Farmer Categories							
Marginal	362.16	14.98	-0.32	-17.36	24.18	-1131.75	-20.86
Small	62.79	1.63	-0.30	-16.97	38.52	-209.3	-3.70
Others	648.55	20.36	2.49	-10.87	31.85	260.46	-59.67

Source: Field Survey of IDSAP, Rabi 2023-24

Table 3.6: Cost efficiency of profitability, efficiencies in input utilisation and Price realisation relative to input costs for Bengal Gram in Rabi for different agroclimatic zones and farmer categories in CNF and Non-CNF systems

Description of Agroclimatic Zones and farmer Categories (1)	Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	non-CNF (3)	CNF (4)	non-CNF (5)	CNF (6)	non-CNF (7)
Zones						
Southern	0.54.	0.28	0.25	0.21	12.25	10.51
Scarce rainfall	-0.16	-0.06	0.13	0.15	12.80	14.70
Farmer Categories						
Marginal	0.51	0.10	0.24	0.18	12.67	10.51
Small	0.58	0.30	0.26	0.21	13.94	11.61
Others	0.46	0.05	0.23	0.17	14.22	12.36

Source: Field Survey of IDSAP, Rabi 2023-24
Note: Ratio of Yields to input costs in multiplied by 1000 to adjust for decimal points and the ratio of crop output price to input cost is multiplied by 100 to adjust for decimal points.

3.4.4. (D). Maize Farming

Maize is a crucial crop predominantly grown in the Krishna and scarce rainfall zones. The dynamics of profit for Maize farmers under the CNF system as compared to non-CNF offer valuable insights into how different farming practices influence profitability, yields, and resource utilization. This analysis delves into the zonal dynamics for both zones, comparing the performance of CNF and non-CNF farmers.

i. Zonal Analysis

(a). Krishna Zone

In the Krishna zone, CNF farmers have demonstrated a 9.59% higher profit than their non-CNF counterparts. The higher profit margins for CNF farmers are primarily attributed to a reduction in input costs, which significantly outpaced the higher costs of production observed among non-CNF farmers. However, despite this cost reduction, lower yields and output prices for CNF farmers have somewhat dampened their profit potential compared to non-CNF farmers. These lower yields are a critical factor that CNF farmers must address for further profitability.

The elasticity analysis reveals that CNF farmers' profit sensitivity to changes in yield, output prices, and input costs is negative. This means that a 1% increase in yield or prices or a 1% reduction in input costs would negatively impact profits, highlighting the importance of improving the underlying farming practices.

Interestingly, CNF farmers are using resources more efficiently than their non-CNF counterparts, achieving yields and profits similar to or even better than those of their non-CNF counterparts while incurring lower input costs. However, the input reduction has led to lower yields than non-CNF farmers. This suggests that CNF farmers may be over-reducing inputs beyond the optimal level. To further increase profits, it is crucial for CNF farmers to adopt all CNF practices to improve soil health, which could potentially enhance crop yields without significant additional costs. This is the most viable option for CNF farmers in this zone to boost profits (Tables 3.7 and 3.8).

(b). Scarce Rainfall Zone

In the areas with scarce rainfall, CNF farmers have faced greater challenges. The profits for CNF farmers in this zone are lower than those of their non-CNF counterparts. CNF farmers have experienced a 21.05% yield reduction compared to non-CNF farmers. While input use has been reduced by 36.97%, the increase in output prices has been minimal, at only 1.69% higher than that of non-CNF farmers.

Despite these setbacks, CNF farmers in the zone with scarce rainfall have efficiently utilized resources to achieve lower costs and realize profits similar to those of their non-CNF counterparts. However, elasticity analysis shows that profit increases are inelastic with respect to yield, output prices, and input costs. This means that changes in these factors have a relatively low impact on profit margins. However, it is still possible to enhance profits by improving both input use and yields. These two factors are interconnected, and improving one can have a positive effect on the other.

One potential strategy for enhancing yields is to adopt mixed cropping systems, where Maize is grown alongside complementary and suitable crops for the region. Mixed cropping can help increase overall yields, improve resource use, and reduce risks associated with the volatile weather conditions that affect the scarce rainfall zone.

Maize farming under the CNF system has the potential for higher profits, especially in the Krishna zone, where cost reduction has already provided a significant profit advantage. However, challenges related to lower yields and lower output prices persist. The key to overcoming these challenges lies in improving soil health practices to boost yields while maintaining the cost efficiencies achieved through CNF practices.

While CNF farmers in the scarce rainfall zone face more significant difficulties, the potential for increased profits still exists. Emphasising mixed cropping and improving input use can help enhance yields and profitability. Ultimately, a combination of effective resource management, market support, and innovative farming practices will determine the future success of CNF farmers in both zones (Tables 3.7 and 3.8).

ii. Farmer Categories Analysis

(a). Marginal Farmers

Marginal farmers practicing CNF have achieved higher profits, 21.16% higher than their non-CNF counterparts. This is primarily due to a 3.04% increase in yield and a 26.36% reduction in input costs. However, there is no price advantage for CNF farmers over non-CNF farmers, suggesting that CNF farmers are not receiving premium prices for their chemical-free crop outputs. Lack of market support is a significant constraint for further profit enhancement.

The elasticity analysis of profit with respect to yield, crop output prices, and input costs reveals that the profit response to input reductions is negative, meaning that further profit gains cannot be achieved by reducing input costs. Conversely, the most effective strategy for increasing profits is improving crop yields, as the elasticity of profit with respect to yield is positive. Therefore, marginal CNF farmers should focus on improving crop yields rather than reducing input use to enhance profits.

One viable strategy for these farmers to boost yield is mixed cropping. This allows marginal farmers to maintain the same level of input use while introducing complementary crops that can improve the overall productivity of the land. This approach would help increase yield without additional inputs, offering a sustainable way to enhance profitability (Tables 3.7 and 3.8).

(b). Small Farmers

Small farmers practicing CNF have achieved 18.73% higher profits than their non-CNF counterparts. The higher profits are primarily due to lower input costs (a reduction of 29.01%) and higher output prices, despite lower yields compared to non-CNF farmers. This indicates that cost reduction and price realization are the key drivers of higher profits for small CNF farmers.

The elasticity analysis indicates that output prices have a positive and elastic response to profits, meaning that increasing output prices can significantly enhance profitability. However, both yield and input costs exhibit negative elasticity with respect to profits, suggesting that increasing input use or relying solely on yield improvements may not lead to improved profit margins. Therefore, the best strategy for small CNF farmers is to secure stronger market access and link them to markets that can fetch higher prices for their chemical-free crop outputs.

Thus, small farmers must strengthen their market linkages to ensure they receive higher crop prices, which in turn leads to increased profits (Tables 3.7 and 3.8).

The analysis of profit dynamics in marginal and small CNF farming systems highlights two critical strategies for enhancing profitability: increasing yields through mixed cropping for marginal farmers and improving market access to secure higher crop prices for small farmers. Both categories of farmers already benefit from efficient resource use, but to achieve sustained profitability, farmers need external support such as better market access for CNF products and continued adoption of soil health-improving practices. This study highlights the significance of market linkages for small farmers and the adoption of sustainable farming practices by marginal farmers to realise the full potential of CNF farming. With the right support and strategies, both categories of farmers can achieve higher profits and improve the sustainability of their farming system.

Table 3.7: Role of yield, prices and paid-out costs in profit-making for Maize in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Increase in Profit of CNF over non-CNF (%) (2)	Increase in Yield of CNF over non-CNF (%) (3)	Increase in Output of CNF over non-CNF (%) (4)	Increase in Paid-out cost of CNF over non-CNF (%) (5)	Elasticities of profit with respect to		
					Yield of Crop (2)/ (3)	Price of crop output (2)/ (4)	Costs inputs (2)/ (5)
Zones							
Krishna	9.59	-2.86	-2.41	-31.56	-3.55	-3.98	-0.30
Scarce rainfall	-7.14	-21.05	1.69	-36.97	0.34	-4.22	0.19
Farmer Categories							
Marginal	21.16	3.04	-0.16	-26.36	6.96	-132.25	-0.80
Small	18.73	-7.49	8.41	-29.01	-2.50	2.22	-0.67
Others	51.11	10.21	0.06	-35.18	5.01	8.51	-1.45

Source: Field Survey of IDSAP, Rabi 2023-24

Table 3.8: Cost efficiency of profitability, efficiencies in input utilisation and price realisation relative to input costs for Maize in Rabi for different agroclimatic zones and farmer categories in CNF and Non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	non-CNF (3)	CNF (4)	non-CNF (5)	CNF (6)	non-CNF (7)
Zones						
Krishna	2.85	1.78	1.83	1.29	4.05	2.84
Scarce rainfall	1.85	1.26	1.36	1.08	4.67	2.96
Farmer Categories						
Marginal	2.57	1.56	1.71	1.22	4.63	3.41
Small	2.62	1.57	1.54	1.18	5.03	3.30
Others	2.53	1.08	1.69	1.00	3.82	2.47

Source: Field Survey of IDSAP, Rabi 2023-24
Note: Ratio of Yields to input costs in multiplied by 1000 to adjust for decimal points and the ratio of crop output price to input cost is multiplied by 100 to adjust for decimal points.

3.4.5. Black Gram Farming

Black Gram is predominantly grown in the HAT (High Altitude and Tribal) zone, North Coastal zone, Godavari, and Krishna zones. This section focuses on the dynamics of profit within zones, comparing CNF and non-CNF farmers in terms of profitability, yield, input use, and output prices.

i. Zonal Analysis

(a). In the HAT zone, CNF farmers have achieved higher profits than their non-CNF counterparts, with an impressive profit margin of 11.18%. This profit increase is primarily driven by higher yields (12.97%) and increased input use (6.87%) among CNF farmers compared to non-CNF farmers. However, it’s essential to note that output prices for CNF farmers are 2.14% lower compared to those realized by their non-CNF counterparts, which negatively impacts their profit potential.

The key to understanding this profit differential lies in resource efficiency. The resource efficiency analysis indicates that CNF farmers can achieve higher profits and yields at lower costs than non-CNF farmers. This is a significant advantage in terms of cost-effectiveness. However, the resource use for realizing output prices is not as efficient for CNF farmers, suggesting that there may be opportunities to improve market linkages or negotiate better prices for their produce.

The elasticity analysis of profits reveals several crucial insights:

The profit elasticity with respect to input costs indicates that CNF farmers' profits are highly responsive to changes in input use. A marginal increase in input use translates to a notable rise in profit. However, this response is inelastic, meaning that while increasing input use does lead to higher yields, the proportional increase in profit is not as substantial as the increase in costs.

The profit response to yield improvements and output prices is less significant. While increasing input use can help boost yields, the returns in terms of profit are less than proportional. Additionally, the lower output prices realized by CNF farmers diminish the potential for significant profit gains.

The analysis points toward a few key policy instruments that could enhance profits for CNF farmers in the HAT zone:

The relatively low profit response to increased input use, combined with the diminishing returns from mono-cropping, suggests that a change to mixed cropping could be a viable solution. Mixed cropping would enable CNF farmers to utilize the same inputs more efficiently and diversify their crop output, thereby reducing the risks associated with monocropping and potentially improving overall profitability.

Since CNF farmers receive lower prices for their crops than non-CNF farmers, improving market linkages and creating stronger support systems to ensure premium prices for chemical-free crop outputs is essential. This could involve policies that connect CNF farmers with organic or niche markets, where higher prices can be realized.

While CNF farmers are more efficient in cost, there is still room for improvement in resource utilization, particularly in relation to output prices. Fostering better market awareness, providing support for better crop storage practices, and facilitating access to price information can further enhance the economic outcomes for CNF farmers.

The dynamics of profit in Black gram farming in the HAT zone highlight both opportunities and challenges for CNF farmers. While they achieve higher profits than non-CNF farmers, the constraints of lower output prices and inelastic profit responses to increased input use necessitate strategic policy interventions. Mixed cropping, stronger market linkages, and optimized resource use offer promising avenues to enhance profitability and support sustainable farming practices in the region. By aligning these factors, CNF farmers in the HAT zone could improve their financial sustainability and contribute to the growth of chemical-free farming in the area (Tables 3.9 and 3.10).

(b). North Coastal Zone

In the North Coastal Zone, CNF farmers have earned 33.87% lower profits than their non-CNF counterparts. The primary factors contributing to the lower profits for CNF farmers include reduced yields (down 24.18%) and lower output prices (down 5.77%), resulting in a less favourable profit scenario for CNF farmers. Moreover, CNF farmers have incurred higher input costs by 24.18% without any corresponding increase in yields.

Additionally, CNF farmers have utilized resources inefficiently compared to non-CNF farmers. This inefficiency is evident in the higher input costs incurred by CNF farmers to achieve profit, yield, and crop output prices, resulting in a situation where there is significant room for improvement through better resource allocation.

The elasticity of profit with respect to various factors reveals that profit is most responsive to changes in output prices (5.87%), followed by changes in yield (1.40%) and input use (1.40%). This suggests that CNF farmers could benefit the most by improving market linkages to secure higher prices for their crop output and increasing input use, which could lead to improved yields. However, increasing input use without addressing resource utilisation efficiency will not directly lead to higher yields.

A possible strategy to enhance yields and thereby profits is to adopt mixed cropping with complementary crops alongside Black gram. This practice, combined with improved input utilisation, could lead to higher yields for CNF farmers compared to their non-CNF counterparts.

The situation of CNF farmers in the North Coastal Zone highlights the importance of both market access and resource management in enhancing farm profitability. While improvements in yield and input costs are essential, market linkages remain a pivotal factor in maximizing profits. Adopting mixed cropping, combined with more substantial market support, could provide a sustainable pathway for CNF farmers to enhance their financial stability and ensure the long-term viability of their farming practices. By combining efficient resource use with diversified cropping systems and market-oriented strategies, CNF farmers can overcome the current challenges and achieve greater profitability (Tables 3.9 and 3.10).

(c). Godavari Zone

CNF farmers in the Godavari zone have experienced a 2.29% lower profit than their non-CNF counterparts. This decline in profit is primarily attributed to a 7.09% decrease in yield, which outweighed the positive impacts of higher output prices (1.74%) and reduced input costs (9.77%) for CNF farmers compared to non-CNF farmers. Despite this, CNF farmers have managed to utilize resources more efficiently in terms of generating profit, yield, and output prices, with lower input costs compared to non-CNF farmers. This indicates that reallocating resources within the CNF system will not increase profits.

The elasticity analysis offers further insights into how changes in output prices, input costs, and yields impact profits. Specifically, an increase in output prices by 1% results in a 1.32% reduction in profit for CNF farmers, suggesting that higher output prices are counterproductive for-profit growth in this zone. At the same time, the relationship between increased input use and profit is inelastic (meaning the profit increase is less than proportional to the increase in input use). A 1% increase in input use results in a 0.23% increase in profit.

This suggests that the link between input use and yield improvement is critical. Although increased inputs lead to marginally higher profits, the response in yield to increased input use is inelastic, meaning the expected yield increase from added inputs is not large enough to boost profits significantly. The key takeaway here is that the same level of input use on the same land should result in higher yields, but this can only be achieved through a shift from monocropping to diversified, multi-cropping practices. Specifically, incorporating complementary crops alongside Black gram on the same piece of land may help improve yields and, in turn, increase profits for CNF farmers.

The Godavari zone presents a clear case where yield improvement is crucial for CNF farmers. While the CNF system offers advantages regarding reduced input costs, the inability to achieve higher yields with the same input levels poses a challenge to maximizing profits. A shift towards multi-cropping systems, using complementary crops alongside Black gram, could solve this issue. By adopting these practices, CNF farmers can harness the full potential of their resources, leading to improved profitability and greater long-term sustainability. Strong market support for CNF products is also necessary to ensure that higher yields are rewarded with competitive prices (Tables 3.9 and 3.10).

(d). Krishna Zone

In the Krishna zone, the comparison of profit dynamics between CNF and non-CNF systems for Black Gram farming has revealed significant differences in profitability. CNF farmers have reported higher profits than their non-CNF counterparts, thanks to reduced input costs and a slight increase in yields. Despite facing lower prices for their produce, CNF farmers have achieved superior profitability due to lower input costs and increased yield.

CNF farmers in the Krishna zone earned 47.39% higher profits than non-CNF farmers. This higher profit can be attributed to two main factors: a reduction in input costs and an increase in yield. The input costs for CNF farmers were 36.63% lower than non-CNF farmers, while their yield increased by 3.12%. Despite this, CNF farmers faced a disadvantage in terms of the price they received for their output, as they earned lower prices than non-CNF farmers. However, the combined cost reduction and increased yield resulted in a higher overall profit for CNF farmers.

Elasticity of Profit

To further understand the dynamics, we analysed the profit elasticity in relation to various factors such as yield, input costs, crop output price, and the shift to mixed cropping.

- Elasticity of profit with respect to yield: A 1% increase in yield for CNF farmers results in a 15.19% increase in profit over their non-CNF counterparts. This highlights the strong relationship between yield and profit, underscoring that yield enhancement is a crucial factor in enhancing profitability.
- Elasticity of profit with respect to input costs: A 1% increase in input costs results in a 1.29% reduction in profits for CNF farmers compared to non-CNF farmers. This relationship underscores the importance of managing input costs for CNF farmers to maintain higher profitability.
- Elasticity of profit with respect to output price: A 1% increase in the cost of the output results in a significant reduction in profits (39.82%) for CNF farmers compared to their non-CNF counterparts. This suggests that CNF farmers have already attained relatively higher output prices, and any further price increase would not be beneficial.
- The introduction of mixed cropping further enhances the dynamics of profit. A shift from monocropping to mixed cropping results in higher yields and increased land productivity, directly leading to increased profits. The elasticity analysis indicates that farmers adopting mixed cropping can expect a substantial increase in yield, optimizing land use and improving farm profitability on the same piece of land with the same level of input use. Thus, mixed cropping is a key strategy to boost profits for CNF farmers.

The CNF system presents a promising model for higher profits in Black Gram farming in the Krishna zone. By focusing on yield improvement through mixed cropping, CNF farmers can continue to increase profitability while optimizing land productivity. Managing input costs remains crucial, as does recognising that further price increases may not lead to increased profitability. Therefore, the future success of CNF farmers in the Krishna Zone lies in enhancing yields through mixed cropping and improving land-use efficiency, ensuring sustainable growth and long-term financial stability (Tables 3.9 and 3.10).

(ii). Farmer Categories Analysis

(a). Marginal Farmers

The profitability dynamics of Black gram cultivation for marginal farmers have been analysed to explore strategies that could further enhance profits for marginal and small-scale farmers, particularly in the context of CNF versus Non-CNF systems.

Marginal farmers practicing CNF have earned 14.07% lower profits than their non-CNF counterparts. This decline in profits is primarily attributed to the following factors:

1. Lower Yields: CNF farmers experienced 11.70% lower yields than non-CNF farmers.
2. Lower Output Prices: The prices obtained for Black gram by CNF farmers were 5.53% lower than those of non-CNF farmers.
3. Reduced Input Costs: While CNF farmers benefited from a 21.41% reduction in input costs, the adverse effects of lower yields and output prices have significantly dampened their profitability.

Despite these challenges, it is worth noting that resource use efficiency in CNF farming is higher than that of non-CNF agriculture. CNF farmers can achieve similar or better yields, output prices, and profits at lower costs than their non-CNF counterparts. In essence, CNF farmers are more efficient in utilizing their resources, although they still face challenges in yield and pricing.

Elasticity of Profit Analysis

To further understand the profit dynamics and potential for improvement, we analysed the elasticity of profit with respect to yield, output price, and input costs for marginal CNF farmers:

1. Elasticity of Profit with Respect to Output Price: A 1% increase in the price of output results in a 2.54% increase in profit for CNF farmers. This suggests that CNF farmers benefit significantly from higher market prices for their produce, enabling them to increase their profits further.
2. Elasticity of Profit with Respect to Yield: A 1% increase in yield leads to a 1.20% increase in profits for CNF farmers. This suggests that improving yield is a viable strategy for boosting profits, albeit at a lower rate than price increases.
3. Elasticity of Profit with Respect to Input Costs: Increasing input costs by 1% results in a 0.66% increase in profits, indicating a less-than-proportional increase. This suggests that increasing inputs is not an effective or sustainable option for CNF farmers to further enhance their profits.

Given the elasticity analysis, the question arises: How can CNF farmers increase yield without increasing input costs?

The only viable solution lies in the shift from monocropping to mixed cropping. By adopting a mixed cropping system, CNF farmers can:

- Increase crop yield by diversifying their farming systems, which can result in higher overall farm productivity.
- Optimising land use efficiency can enhance land productivity on the same piece of land with the same level of input use.
- Improve soil health and reduce pest risks, both of which contribute to sustained increases in crop yield without additional costs.

Therefore, the shift to mixed cropping is a necessary and non-negotiable strategy for marginal CNF farmers to enhance long-term profitability (Tables 3.9 and 3.10).

While marginal CNF farmers currently face challenges in profitability due to lower yields and prices, there is significant potential for profit growth by focusing on yield improvement and better market prices. Adopting mixed cropping as a non-negotiable strategy is the key to unlocking this potential. This shift will enable farmers to enhance land productivity, increase yields, and maintain profitability without incurring additional input costs. Therefore, the future success of marginal CNF farmers depends on optimizing their farming systems through mixed cropping, resulting in more resilient and profitable farming practices in the long run.

(b). Small Farmers

Small farmers practicing CNF have experienced an 8.16% decrease in profits compared to their non-CNF counterparts. This disparity in profits can be attributed to several factors:

- Lower Yields: CNF farmers have reported yields 12.67% lower than non-CNF farmers.
- Higher Output Prices: CNF farmers received 1.44% higher prices for their Black gram than non-CNF farmers.
- Lower Input Costs: CNF farmers have benefited from a 21.71% reduction in input costs, contributing to lower production expenses.

While CNF farmers have lower input costs and higher output prices, the lower yields more than offset these advantages, resulting in reduced profitability overall for CNF farmers compared to their non-CNF counterparts.

Despite this, CNF farmers have demonstrated higher resource use efficiency, meaning they can generate profits, yields, and output prices at lower costs than their non-CNF counterparts. However, due to the limitations in yields, there is little room for reallocating resources or improving profitability further without addressing the key factor of yield enhancement.

Elasticity of Profit Analysis

A detailed analysis of the elasticity of profit with respect to yield, output price, and input use provides deeper insights into the factors influencing profit dynamics:

Elasticity of Profit with Respect to Output Price: A 1% increase in output price for CNF farmers results in a 5.67% reduction in profits compared to non-CNF farmers. This suggests that further increasing the output price would not contribute to enhanced profitability, as CNF farmers are already receiving relatively higher crop prices. Any further price increase appears to yield diminishing returns.

Elasticity of Profit with Respect to Input Use: A 1% increase in input use results in a 0.38% increase in profits. This indicates that increasing inputs does not provide a proportional return on investment and is therefore not a viable strategy for enhancing profits for CNF farmers.

Elasticity of Profit with Respect to Yield: The analysis reveals that improving yield is the primary driver of increased profits. However, yield improvements cannot be achieved simply by increasing input use on the same piece of land. This suggests that the most effective strategy for improving yield and profitability for CNF farmers is to shift from monocropping to mixed cropping. By diversifying crop types, CNF farmers can achieve better land productivity and higher yields without increasing input costs.

Shift to Mixed Cropping: A Necessary Strategy

The only viable strategy for further enhancing profits for small CNF farmers is to adopt mixed cropping over monocropping. This approach would allow farmers to:

- Increase Yield: Mixed cropping can lead to higher overall crop yields by diversifying the farming system and optimising land use.

- Enhance Land Productivity: Farmers can increase land productivity without additional input costs, making it a more cost-effective strategy for profit enhancement.
- Improve Soil Health: Mixed cropping promotes healthier soil by reducing the risk of soil depletion and pest infestations, which can negatively impact yields.

Thus, transitioning from monocropping to mixed cropping on the same piece of land with the same level of inputs is the most sustainable and effective strategy for boosting profitability among small CNF farmers.

The current profit dynamics for small CNF farmers reveal that while Natural Farming offers clear advantages in lower input costs and higher prices, the limiting factor for increasing profitability remains the lower yield. The transition from monocropping to mixed cropping emerges as the key strategy to enhance both yield and land productivity on the same piece of land with the same input levels. This shift will allow small CNF farmers to achieve sustainable profitability in the long run. The future success of small CNF farmers hinges on their ability to adopt mixed cropping to diversify their crops, optimize resource utilisation, and ultimately achieve better financial outcomes (Tables 3.9 and 3.10).

Table 3.9: Role of yield, prices and paid-out costs in profit-making for Black gram in Rabi for different agroclimatic zones and farmer categories in CNF and non-CNF systems

Agroclimatic Zones and farmer Categories (1)	Increase in Profit of CNF over non-CNF (%) (2)	Increase in Yield of CNF over non-CNF (%) (3)	Increase in Output of CNF over non-CNF (%) (4)	Increase in Paid-out cost of CNF over non-CNF (%) (5)	Elasticities of profit with respect to		
					Yield of Crop (2)/ (3)	Price of crop output (2)/ (4)	Costs of inputs (2)/ (5)
Zones							
HAT	11.18	12.97	-2.14	6.87	0.86	-5.22	1.63
North Coastal	-33.87	-24.18	-5.77	24.18	1.40	5.87	1.40
Godavari	-2.29	-7.09	1.74	-9.77	0.32	-1.32	0.23
Krishna	47.39	3.12	-1.19	-36.63	15.19	-39.82	-1.29
Farmer Categories							
Marginal	-14.07	-11.70	-5.53	-21.41	1.20	2.54	0.66
Small	-8.16	-12.67	1.44	-21.71	0.64	-5.67	0.38
Others	-6.43	-12.30	6.64	19.18	0.52	-0.96	0.34

Source: Field Survey of IDSAP, Rabi 2023-24

Table 3.10 Cost efficiency of profitability, efficiencies in input utilisation and price realisation relative to input costs for Black gram in Rabi for different agroclimatic zones

and farmer categories in CNF and Non-CNF system.

Agroclimatic Zones and farmer Categories (1)	Paddy Farming efficiencies for CNF and non-CNF farmers					
	Ratio of Profit to Input Costs		Ratio of Yield to Input cost		Ratio of crop output price to input costs	
	CNF (2)	non-CNF (3)	CNF (4)	non-CNF (5)	CNF (6)	non-CNF (7)
Zones						
HAT	6.04	5.78	0.97	0.92	56.27	61.45
North Coastal	5.28	9.91	0.89	1.46	62.96	82.96
Godavari	1.46	1.35	0.35	0.34	21.44	19.02
Krishan	1.97	0.85	0.32	0.20	24.22	15.53
Farmer Categories						
Marginal	3.52	3.22	0.61	0.54	42.83	35.63
Small	3.72	3.17	0.60	0.54	40.81	31.50
Others	*4.37*	*5.57*	*0.66*	*0.85*	*44.61*	*49.86*

Source: Field Survey of IDSAP, Rabi 2023-24
Note: Ratio of yields to input costs in multiplied by 1000 to adjust for decimal points. And the ratio of crop output price to input cost is multiplied by 100 to adjust for decimal points.

3.5. Summary of Results – Deriving Patterns in Profit Behaviour Across Agroclimatic Zones and Farmer Categories

This section synthesizes the findings of the elasticity analysis and the broader investigation into profit behavior across agroclimatic zones and farmer categories. The objective was to test a fundamental hypothesis:

Is profit behavior determined by the nature of the crop, or by the nature of the farmer's resource base?

By analysing both descriptive and elasticity-based data, this chapter presents patterns that are not only academically robust but also actionable for practitioners, communities, and policymakers.

3.5.1. Zonal Analysis: Patterns in Profit Dynamics

The elasticity analysis conducted across agroclimatic zones reveals key insights into how contextual factors—such as market strength, resource endowment, and crop diversity—influence profitability in CNF relative to chemical/ non-CNF systems.

Key Patterns Identified:

Market Linkages in Resource-Poor Zones

In zones like HAT (tribal), North Coastal, Southern, and Scarce Rainfall, market constraints significantly limit profit realization. Enhancing market access and price support for CNF farmers is critical. Connecting these regions to premium or niche markets can bridge profitability gaps.

Price Support Less Effective in Resource-Rich Zones

In well-connected zones such as Godavari and Krishna, CNF farmers already achieve premium prices due to strong market linkages. Further price support has diminishing returns. Interventions here should focus on innovation, diversification, and scaling.

Input Efficiency Mirrors Market Maturity

In resource-rich regions, CNF farmers benefit from well-developed input markets—especially for biological and eco-friendly inputs—enabling efficient and profitable input use.

Input Constraints in Resource-Poor Zones

The lack of organized input markets in poorer zones leads to variation in input efficiency and potential underperformance in CNF systems. Investment in input supply infrastructure and extension networks is needed.

From Yield to Land Productivity – A Strategic Shift

Yield improvements alone are insufficient. A transition from monocropping to mixed cropping is vital across all zones. This agroecological shift enhances land use efficiency, promotes biodiversity, and supports sustainable profit growth.

Crop vs. Zone-Specific Interventions

In **resource-rich zones**, profit behavior tends to be **homogeneous across crops**, allowing for **zone-level strategies**.

In **resource-poor zones**, profit responses are **crop-specific**, requiring **localized and crop-tailored interventions**.

3.5.2. Farmer Category Analysis: Profit Dynamics of Marginal and Small Farmers

A parallel analysis across marginal and small farmers reveals consistent patterns in their profit optimization strategies, shaped less by the type of crop and more by the resource base of the farmer.

Emerging Patterns

***Input Use Efficiency*:**

Inputs are generally used at or near optimal levels. Increases in input use yield diminishing or negative returns, indicating that input intensification is not be a viable strategy for further profit growth.

***Yield-Based Gains are Limited*:**

Elasticity estimates suggest that yield improvements alone do not significantly enhance profits unless accompanied by a change in cropping systems or farming practices.

Premium Prices Not Universally Accessible:

In several cases, small and marginal CNF farmers already realize higher-than-market prices through contracts or niche markets. This limits the room for price-based interventions as a profit lever.

Mixed Cropping as a Common Strategy:

Across both marginal and small farmers, shifting from monocropping to mixed cropping consistently emerges as the most viable pathway for enhancing profits—*without increasing input costs or relying on price hikes*.

3.5.3. Core Insight: Resource Base Over Crop Type

The results strongly support the hypothesis that:

It is the nature of the farmer's resource base—not the nature of the crop—that determines profit behaviour.

This holds true across both zones and farmer categories, highlighting the importance of designing strategies that are farmer- and resource-centric, rather than crop-centric.

3.5.4. Implications for Policy

Policy Recommendations:

- **Strengthen market access** for CNF produce in resource-poor zones.
- **Invest in input delivery systems**, especially in tribal and rainfed areas.
- **Promote mixed cropping systems** through targeted extension programs.
- **Design support mechanisms** that are responsive to farmer categories and zone-specific needs.

3.5.4. Final Reflection

This analysis highlights a fundamental shift in understanding profit optimization in farming. It reveals that sustainable profit enhancement does not rely solely on what is grown, but how and under what conditions it is grown. For marginal and small farmers practicing CNF, the most promising gains lie in agroecological diversification, market access, and tailored resource support—not in conventional input-heavy or price-dependent strategies.

Appendix Tables: Chapter – 3

Appendix Table 3.1: Agroclimatic zones-wise and farmers' categories-wise number of CNF and non-CNF CCEs conducted of selected crops during Rabi 2023-24

Agroclimatic Zones & Categories of farmers	Paddy		Groundnut		Bengal gram		Maize		Black gram		Green gram		Ragi	
	CNF	non-CNF	CNF	non-CNF	CNF	non-CNF	CNF	non-CNF	CNF	non-CNF	CNF	non-CNF	CNF	non-CNF
Zone														
HAT	85	24					27	1	16	18	7	1	44	16
North coastal	8				1		17	9	104	38	8	13	5	
Godavari	85	27					3	9	10	17	9	7		
Krishna					85	69	36	20	40	45	13	4		
Southern	45	13	37	12	16	30	2	1	2			5		
Scarce rainfall	6	1	26	27	22		43	20	2					
Total	229	65	63	39	124	99	128	60	174	118	37	30	49	16
Farm size category														
Marginal	156	37	39	18	79	44	82	41	129	84	26	23	31	5
Small	49	20	12	14	35	39	30	12	34	27	8	6	13	6
Others	24	8	12	7	10	16	16	7	11	7	3	1	5	5
Total	229	65	63	39	124	99	128	60	174	118	37	30	49	16

Source: IDSAP Field Survey 2023-24

Appendix Table 3.2: Agroclimatic zone-wise and farmers' categories-wise costs, yields and value of output of Paddy in Rabi 2023-2024

Agroclimatic Zones & Categories of farmers	Paid-out cost					CCE yields					Prices				
	₹/ hectare		sig	Difference between CNF & non-CNF		quintals/ hectare		sig	Difference between CNF & non-CNF		Rs per Qtl		sig	Difference between CNF & non-CNF	
	CNF	non-CNF		₹/ hectare	in %	CNF	non-CNF		(₹ / ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %
Zone															
HAT	15,640	13,106	*	2,535	19.34	36.11	28.19	**	7.92	28.10	1,603	1,642	ns	-38.64	-2.35
North coastal	43,196			43,196		49.63			49.63		2,264				
Godavari	45,161	71,185	**	-26,024	-36.56	62.11	63.39	ns	-1.28	-2.01	2,046	1,919	**	127.42	6.64
Krishna															
Southern	55,750	95,063	**	-39,313	-41.35	49.53	48.59	ns	0.94	1.93	2,191	2,123	ns	67.55	3.18
Scarce rainfall	46,486	73,764	na	-27,278	-36.98	55.64	43.54	na	12.10	27.79	2,275	1,850	na	425.00	22.97
Total	36,713	42,725	*	-6,012	-14.07	49.38	47.13	ns	2.26	4.79	1,929	1,793	*	135.49	7.56
Farm size category															
Marginal	38,125	55,679	**	-17,555	-31.53	50.55	52.24	ns	-1.70	-3.25	1,941	1,811	ns	130.33	7.20
Small	34,238	22,519	**	11,719	52.04	48.57	44.83	ns	3.73	8.32	1,897	1,732	ns	164.98	9.53
Others	30,329	11,629	**	18,700	160.81	43.48	29.18	**	14.30	49.00	1,902	1,835	ns	67.29	3.67
Total	36,713	42,725	*	-6,012	-14.07	49.38	47.13	ns	2.26	4.79	1,929	1,793	*	135.49	7.56

Appendix Table 3. 2 Continues

Agroclimatic Zones & Categories of farmers	Gross value of output				Net value of output			
	₹/ hectare		Difference between CNF & non-CNF		₹ / hectare		Difference between CNF & non-	
	CNF	non-CNF	(₹/ ha.)	in %	CNF	non-CNF	(₹/ ha.)	in %
Zone								
HAT	64,948	53,579	11,370	21.22	49,308	40,473	8,835	21.83
North coastal	1,19,717		1,19,717		76,521	-	76,521	
Godavari	1,34,512	1,26,473	8,038	6.36	89,350	55,288	34,062	61.61
Krishna								
Southern	1,15,339	1,11,338	4,001	3.59	59,589	16,276	43,313	266.12
Scarce rainfall	1,34,408	92,906	41,502	44.67	87,922	19,142	68,781	359.32
Total	1,02,405	91,165	11,240	12.33	65,692	48,440	17,252	35.61
Farm size category								
Marginal	1,05,265	1,01,047	4,217	4.17	67,140	45,368	21,772	47.99
Small	98,981	84,133	14,848	17.65	64,743	61,614	3,129	5.08
Others	90,986	62,034	28,952	46.67	60,657	50,405	10,252	20.34
Total	1,02,405	91,165	11,240	12.33	65,692	48,440	17,252	35.61

Source: IDSAP Field Survey 2023-24

Appendix Table 3.3: Agroclimatic zone-wise and farmers' categories-wise costs, yields and value of output of Groundnut in Rabi 2023-2024

Agroclimatic Zones & Categories of farmers	Paid-out cost					CCE yields					Prices				
	₹/ hectare		sig	Difference between CNF & non-CNF		quintals/ hectare		sig	Difference between CNF & non-CNF		Rs per Qtl		sig	Difference between CNF & non-CNF	
	CNF	non-CNF		(₹/ ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %
Zone															
Southern	77,636	90,905	**	-13,270	-14.60	26.56	27.00	ns	-0.44	-1.62	6,402	6,043	ns	358.56	5.93
Scarce rainfall	93,768	96,028	ns	-2,260	-2.35	24.33	20.26	*	4.07	20.11	6,477	6,399	ns	77.92	1.22
Total	83,896	94,398	*	-10,502	-11.13	25.64	22.33	**	3.31	14.82	6,431	6,286	ns	145.12	2.31
Farm size category															
Marginal	82,614	94,652	ns	-12,038	-12.72	25.66	21.87	*	3.79	17.32	6,392	6,448	ns	-55.80	-0.87
Small	75,836	88,364	ns	-12,528	-14.18	23.36	23.58	ns	-0.21	-0.91	6,381	6,229	ns	152.80	2.45
Others	93,488	1,07,404	*	-13,916	-12.96	27.87	21.03	*	6.83	32.48	6,564	6,050	**	513.75	8.49
Total	83,896	94,398	*	-10,502	-11.13	25.64	22.33	**	3.31	14.82	6,431	6,286	ns	145.12	2.31

Appendix Table 3. 3 Continues

Agroclimatic Zones & Categories of farmers	Gross value of output				Net value of output			
	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between Net value of CNF & non-CNF output (₹/ hectare)	
	CNF	non-CNF	(₹/ ha.)	in %	CNF	non-CNF	(₹/ ha.)	in %
Zone								
Southern	1,81,629	1,75,147	6,482	3.70	1,03,993	84,241	19,752	23.45
Scarce rainfall	1,73,933	1,47,766	26,167	17.71	80,165	51,738	28,427	54.95
Total	1,78,329	1,56,554	21,775	13.91	94,433	62,156	32,277	51.93
Farm size category								
Marginal	1,77,664	1,59,999	17,666	11.04	95,050	65,347	29,703	45.46
Small	1,61,829	1,60,682	1,146	0.71	85,993	72,319	13,674	18.91
Others	1,96,350	1,42,381	53,969	37.90	1,02,862	34,978	67,884	194.08
Total	1,78,329	1,56,554	21,775	13.91	94,433	62,156	32,277	51.93

Source: IDSAP Field Survey 2023-24

Appendix Table 3.4: Agroclimatic zone-wise and farmers' categories-wise costs, yields and value of output of Bengal gram in Rabi 2023-2024

Agroclimatic Zones & Categories of farmers	Paid-out cost					CCE yields					Prices				
	₹/ hectare		sig	Difference between CNF & non-CNF		quintals/ hectare		sig	Difference between CNF & non-CNF		Rs per Qtl		sig	Difference between CNF & non-CNF	
	CNF	non-CNF		(₹ / ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %
Agroclimatic zones															
Krishna	50,464	59,225	**	-8,762	-14.79	12.61	12.15	ns	0.46	3.78	6,180	6,224	ns	-44.42	-0.71
Southern	48,986	41,166	**	7,820	19.00	6.57	6.38	ns	0.19	2.97	6,272	6,050	**	221.62	3.66
Total	46,680	54,555	**	-7,875	-14.43	11.66	10.40	ns	1.25	12.03	6,200	6,179	ns	21.05	0.34
Farm size category															
Marginal	48,934	59,213	**	-10,279	-17.36	11.95	10.39	ns	1.56	14.98	6,201	6,221	ns	-20.06	-0.32
Small	44,370	53,441	**	-9,072	-16.97	11.37	11.18	ns	0.18	1.63	6,184	6,202	ns	-18.30	-0.30
Others	43,752	49,086	*	-5,333	-10.87	10.27	8.53	ns	1.74	20.36	6,220	6,069	*	151.14	2.49
Total	46,680	54,555	**	-7,875	-14.43	11.66	10.40	ns	1.25	12.03	6,200	6,179	ns	21.05	0.34

Appendix Table 3. 4 Continues

Agroclimatic Zones & Categories of farmers	Gross value of output				Net value of output			
	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between CNF & non-CNF (₹/ hectare)	
	CNF	non-CNF	(₹/ ha.)	in %	CNF	non-CNF	(₹/ ha.)	in %
Krishna	77,951	75,654	2,297	3.04	27,487	16,429	11,059	67.31
Southern	41,175	38,575	2,600	6.74	-7,811	-2,591	-5,220	201.48
Scarce rainfall								
Total	72,267	64,285	7,982	12.42	25,587	9,731	15,856	162.95
Farm size category								
Marginal	74,105	64,659	9,446	14.61	25,171	5,446	19,724	362.16
Small	70,285	69,361	924	1.33	25,915	15,920	9,996	62.79
Others	63,865	51,772	12,092	23.36	20,113	2,687	17,426	648.55
Total	72,267	64,285	7,982	12.42	25,587	9,731	15,856	162.95

Source: IDSAP Field Survey 2023-24

Appendix Table 3.5: Agroclimatic zone-wise and farmers' categories-wise costs, yields and value of output of Maize in Rabi 2023-2024

Agroclimatic Zones & Categories of farmers	Paid-out cost					CCE yields					Prices				
	₹/ hectare		sig	Difference between CNF & non-CNF		quintals/ hectare		sig	Difference between CNF & non-CNF		₹ per Qtl		sig	Difference between CNF & non-CNF	
	CNF	non-CNF		(₹/ ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %	CNF	non-CNF		(₹/ ha.)	in %
Zone															
HAT	49,533	43,773	ns	5,761	13.16	98.30	42.53	na	55.78	131.16	2,100	2,000	na	100.00	5.00
North coastal	39,173	37,519	ns	1,654	4.41	60.57	40.37	*	20.20	50.02	2,061	2,014	*	46.82	2.32
Godavari	60,243	71,700	ns	-11,458	-15.98	54.58	72.38	**	-17.80	-24.59	4,600	2,300	na	2,300.00	100.00
Krishna	51,738	75,591	**	-23,853	-31.56	95.03	97.83	ns	-2.79	-2.86	2,098	2,150	*	-51.79	-2.41
Southern	48,171	77,421	na	-29,250	-37.78	58.50	61.25	na	-2.75	-4.48	2,000	2,000	na	-	-
Scarce rainfall	43,773	69,450	**	-25,677	-36.97	59.35	75.17	**	-15.82	-21.05	2,093	2,059	*	34.73	1.69
Total	46,331	64,488	**	-18,157	-28.16	77.64	76.31	ns	1.33	1.74	2,152	2,104	ns	47.85	2.27
Farm size category															
Marginal	45,088	61,228	**	-16,140	-26.36	76.98	74.70	ns	2.27	3.04	2,086	2,089	ns	-3.28	-0.16
Small	46,581	65,612	**	-19,031	-29.01	71.81	77.63	ns	-5.82	-7.49	2,345	2,163	ns	181.84	8.41
Others	54,323	83,805	**	-29,482	-35.18	91.97	83.45	ns	8.52	10.21	2,073	2,071	ns	1.30	0.06
Total	46,331	64,488	**	-18,157	-28.16	77.64	76.31	ns	1.33	1.74	2,152	2,104	ns	47.85	2.27

Appendix Table 3. 5 continues

Agroclimatic Zones & Categories of farmers	Gross value of output				Net value of output			
	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between Net value of CNF & non-CNF output (₹/ hectare)	
	CNF	non-CNF	(₹/ ha.)	in %	CNF	non-CNF	(₹/ ha.)	in %
Zone								
HAT	2,06,435	85,053	1,21,382	142.71	1,56,902	41,281	1,15,621	280.09
North coastal	1,24,844	81,326	43,518	53.51	85,671	43,807	41,864	95.56
Godavari	2,51,077	1,66,475	84,602	50.82	1,90,835	94,775	96,060	101.36
Krishna	1,99,396	2,10,324	-10,928	-5.20	1,47,658	1,34,733	12,925	9.59
Southern	1,20,464	1,26,205	-5,741	-4.55	72,293	48,784	23,509	48.19
Scarce rainfall	1,24,772	1,56,676	-31,905	-20.36	80,998	87,226	-6,228	-7.14
Total	1,67,379	1,61,296	6,084	3.77	1,21,049	96,808	24,241	25.04
Farm size category								
Marginal	1,60,779	1,56,712	4,067	2.60	1,15,691	95,483	20,208	21.16
Small	1,68,625	1,68,400	224	0.13	1,22,044	1,02,788	19,256	18.73
Others	1,91,569	1,74,629	16,940	9.70	1,37,246	90,824	46,422	51.11
Total	1,67,379	1,61,296	6,084	3.77	1,21,049	96,808	24,241	25.04

Source: IDSAP Field Survey 2023-24

Appendix Table 3.6: Agroclimatic zone-wise and farmers' categories-wise costs, yields and value of output of Black gram in Rabi 2023-2024

Agroclimatic Zones & Categories of farmers	Paid-out cost					CCE yields					Prices				
	₹/ hectare			Difference between CNF & non-CNF		quintals/ hectare			Difference between CNF & non-CNF		Rs per Qtl			Difference between CNF & non-CNF	
	CNF	non-CNF	sig	(₹/ ha.)	in %	CNF	non-CNF	sig	(₹/ ha.)	in %	CNF	non-CNF	sig	(₹/ ha.)	in %
Zones															
HAT	12,878	12,051	ns	827	6.87	12.46	11.03	ns	1.43	12.97	7,247	7,405	ns	-158.63	-2.14
North coastal	11,217	9,033	**	2,184	24.18	9.97	13.16	**	-3.18	-24.18	7,062	7,494	**	-432.04	-5.77
Godavari	32,877	36,438	ns	-3,561	-9.77	11.47	12.34	ns	-0.88	-7.09	7,050	6,929	*	120.59	1.74
Krishna	37,360	58,953	**	-21,593	-36.63	12.26	11.89	ns	0.37	3.12	9,047	9,156	**	-108.86	-1.19
Total	17,572	21,987	**	-4,415	-20.08	10.84	12.23	**	-1.50	-12.24	7,489	7,778	**	-288.87	-3.71
Farm size category															
Marginal	17,209	21,897	*	-4,688	-21.41	10.54	11.83	**	-1.38	-11.70	7,370	7,801	**	-431.02	-5.53
Small	19,221	24,551	ns	-5,330	-21.71	11.56	13.23	*	-1.68	-12.67	7,845	7,733	ns	111.18	1.44
Others	18,271	15,330	ns	2,941	19.18	12.05	13.18	ns	-1.62	-12.30	8,150	7,643	ns	507.14	6.64
Total	17,572	21,987	**	-4,415	-20.08	10.84	12.23	**	-1.50	-12.24	7,489	7,778	**	-288.87	-3.71

Appendix Table 3. 6 continues

Agroclimatic Zones & Categories of farmers	Gross value of output				Net value of output			
	₹/ hectare		Difference between CNF & non-CNF		₹/ hectare		Difference between Net value of CNF & non-CNF output (₹/ hectare)	
	CNF	non-CNF	(₹/ ha.)	in %	CNF	non-CNF	(₹/ ha.)	in %
Zones								
HAT	90,331	81,713	8,618	10.55	77,453	69,662	7,791	11.18
North coastal	70,443	98,595	-28,151	-28.55	59,227	89,562	-30,335	-33.87
Godavari	80,835	85,520	-4,685	-5.48	47,958	49,082	-1,124	-2.29
Krishna	1,10,935	1,08,870	2,065	1.90	73,574	49,917	23,658	47.39
Total	81,146	95,146	-14,000	-14.71	63,574	73,159	-9,585	-13.10
Farm size category								
Marginal	77,717	92,310	-14,592	-15.81	60,509	70,413	-9,904	-14.07
Small	90,644	1,02,324	-11,680	-11.41	71,423	77,773	-6,350	-8.16
Others	98,179	1,00,732	-2,554	-2.54	79,907	85,402	-5,495	-6.43
Total	81,146	95,146	-14,000	-14.71	63,574	73,159	-9,585	-13.10

Source: IDSAP Field Survey 2023-24

Chapter 4

Family female labour use and production efficiency for major crops in CNF

4.1. Introduction

Family female labour is critical in agricultural production efficiency for crops such as Paddy, Groundnut, Maize, Bengal gram, and Black gram. The analysis focuses on contrasting two farming systems- CNF and non-CNF. The primary aim is to understand how female family labour influences productivity in both systems.

Though various control variables, such as land size, male family labour, hired labour, capital (input costs excluding hired labour and biological/chemical inputs), biological inputs/ chemical inputs, agro-climatic conditions, and farmer categories influence production and productivity, this chapter narrows the focus to family female labour. The influence of this key variable is studied while considering the other influencing factors as controls.

4.2. Research Issues

The following research questions guide the analysis of female family labour to agricultural production and productivity:

Issue 1: How does family female labour contribute to agricultural production and productivity in both CNF and non-CNF systems?

Issue 2: What is the nature of the relationship between family female labour and production or yield? Does this relationship exhibit increasing returns, diminishing returns, or reach a plateau?

Issue 3: What barriers are to optimizing female family labour in farming systems, and what policy interventions could enhance its contribution?

4.3. Methodology

This study uses a two-layer analysis to assess the relationship between female family labour and agricultural production and productivity.

Layer 1: Production Function Analysis

The first layer estimates Cobb-Douglas production functions for crops under CNF and non-CNF systems. This helps characterise the relationship between inputs and outputs. Yield function analysis is also conducted to understand the yield dynamics of different inputs, including family female labour.

Layer 2: Female Family Labour Analysis

The second layer focuses specifically on female family labour dynamics and its contribution to production and productivity in both farming systems. The two regression models used for analysis are as follows:

Model 1 (Cobb-Douglas Production Function):

Dependent variable: Physical output in quintals

Key Independent Variable: Female family labour (measured in hours worked by female family members)

Control Variables: Land under major crop (hectares), male family labour (number of hours), hired labour (number of hours), input costs (excluding hired labour and biological inputs for CNF or chemical inputs for non-CNF, in rupees), biological inputs in rupees (for CNF), chemical inputs in rupees (for non-CNF), agro-climatic zones (dummy variables, reference zone differs across crop depending upon the crop grown in zones), and farmer categories (marginal farmers as the reference group). The functional form in logarithms is as follows:

ln Output= a+B1 ln family female labour+B2 ln land+B3 ln family male labour+B4 ln hired labour+B5 ln input costs+B6 ln biological inputs (for CNF)/Chemical inputs (for non-CNF) +zonal dummies +farmer category dummies +e

Model 2 (Yield Function):

Dependent Variable: Yield in quintals per hectare

Key Independent Variable: Family female labour per hectare (measured in hours worked by female family members per hectare)

Control Variables: As in Model 1, but adjusted per hectare. The yield function is as follows:

Ln yield= a+B1 ln family female labour++B2 ln family male labour+B3 ln hired labour+B4 ln input costs+B5 ln biological inputs (for CNF)/Chemical inputs (for non-CNF) +zonal dummies +farmer category dummies+e

The Cobb-Douglas production function helps model the relationship between land, labour, and capital inputs. In contrast, the yield function offers insights into per-hectare productivity about labour and capital. The ordinary least squares (OLS) method is used to estimate the functions.

4.4. 4.4 Analysis

4.4.1. Paddy Farming: A Comparative Production System Analysis

In this section, we compare the CNF and non-CNF production systems for Paddy farming, using the control variables to highlight the differences in their responses to inputs. The regression results are presented in Table 4.1.

Table 4.1: Family Female Labour Use, Production(Output) and Productivity (Yield) of Paddy Farming

Description of variables	Model1: Cobb-Douglas Production (Output) function				Model 2: Yield function			
	Paddy				Paddy			
	CNF		non-CNF		CNF		non-CNF	
Constant	3.1792	***	-0.7283	NS	1.0443	NS	-0.3394	NS
	(0.1140607)		(0.1511656)		(1.140728)		(1.386959)	
Area in hectares	0.7031	***	0.6125	***				
	(0.1140607)		(0.1511656)					
Family Labour Male (Hrs)	-0.1927	**	-0.0406	NS	-0.0086	NS	-0.0995	NS
	(0.0828327)		(0.118028)		(0.0616451)		(0.1164105)	
Family Labour Female (Hrs)	-0.0028		0.0004	NS	-0.0007	NS	-0.0001	NS
	(0.0024444)		(0.0037406)		(0.0017596)		(0.0035992)	
Total Hired Labour (Hrs)	0.0078		0.0256	***	0.0047	NS	0.0255	***
	(0.0059453)		(0.006066)		(0.0071958)		(0.0082355)	
Cost without hired labour and PNPI (₹)	0.0916		0.4542	**	0.2068	NS	0.4490	***
	(0.128013)		(0.1818034)		(0.1290687)		(0.1702851)	
PNPI (₹)	0.0723	***	0.0450	***	0.0664	***	0.0434	***
	(0.0103966)		(0.0105248)		(0.0140471)		(0.0132345)	
zone2	0.2467	NS			0.3782	**		
	(0.1524041)				(0.1818757)			
zone3	0.6124	***	0.0382		0.6457	***	0.0742	
	(0.1032423)		(0.1238386)		(0.1223549)		(0.1156155)	

Description of variables	Model1: Cobb-Douglas Production (Output) function				Model 2: Yield function			
	Paddy				Paddy			
	CNF		non-CNF		CNF		non-CNF	
zone5	0.3338	**	-0.5640	***	0.2330	NS	-0.5349	***
	(0.1453112)		(0.2089139)		(0.1596554)		(0.192011)	
zone6	0.4314	***	-0.2945	*	0.3296	**	-0.2653	*
	(0.1231867)		(0.1539809)		(0.1477679)		(0.1444877)	
small	-0.0444	NS	-0.0326		-0.0946	NS	-0.0280	
	(0.0766902)		(0.108957)		(0.0795433)		(0.1126655)	
others	0.0420	NS	-0.0049		0.0722		0.0131	
	(0.0982064)		(0.1021811)		(0.0920332)	NS	(0.1106005)	
Observations	236		98		236		98	
R-square	0.6162		0.7758		0.5081		0.6682	

Note: 1. Figures in parentheses are Robust Standard Errors
*Note 2. ***, ** and * indicate 1%, 5% and 10% significance levels, respectively. NS-Not Significant*
Source: Field Survey of IDSAP, Rabi 2023-24

i. Response to Inputs

The output for Paddy farming is more responsive to land input in CNF compared to non-CNF. Under CNF, biological inputs have a more substantial effect on production than chemical inputs, whereas in non-CNF, chemical inputs dominate. Furthermore, the CNF system shows lower responsiveness to capital inputs (e.g., machinery, equipment) and hired labour, compared to non-CNF, which relies more on these inputs.

ii. Family Labour's Role

The CNF system is characterized by greater dependence on family labour, particularly female family labour. Interestingly, family female labour in CNF is more directly associated with output than in the non-CNF system. This suggests that the CNF system is less capital-intensive and relies more heavily on family labour, with family female labour playing a crucial role in productivity.

iii. Production Function Results Pertaining to Paddy

The production function analysis reveals that, under the CNF system, family female labour has an insignificant relationship with output and yield, indicating a **plateau effect**. This suggests that family female labour has reached its capacity for increasing productivity within the same system, leading to diminishing returns when increased beyond a certain threshold.

Any further use of female family labour beyond this point, or a reduction before reaching the plateau, will lead to diminishing returns in both production and productivity.

Given these findings, the challenge is to shift the production function above its current level, thus overcoming the plateau and enhancing productivity. One potential solution is to implement mixed cropping systems, where different crops are grown on the same land with the same level of female family labour and other inputs. This could help optimize the use of available labour and improve land and crop productivity.

Further steps might include **improved seed technology** and **mechanization** tailored to CNF farmers, significantly to ease the burden on family female labour while enhancing productivity.

4.4.2. Groundnut Farming

CNF and non-CNF production systems for Groundnut farming. Control variables are used here to highlight the differences in their responses to various inputs. This analysis is framed similarly to CNF to the Paddy farming analysis to allow for comparative insights. The regression results are presented in Table 4.2.

Table 4.2: Family female labour use, production(output) and productivity(yield) of Groundnut farming

Description of Variables	Model 1: Cobb-Douglas Production (Output) function				Model 2: Yield function			
	Groundnut				Groundnut			
	CNF		non-CNF		CNF		Non-CNF	
Constant	2.5778	NS	-0.6885	NS	0.6790	NS	-1.8093	NS
	(2.461741)		(0.2136831)		(1.671412)		(2.327436)	
Area in hectares	0.7266	***	0.6559	***				
	(0.1782804)		(0.2136831)					
Family Labour Male (Hrs)	0.0007	NS	-0.0226	*	-0.0020	NS	-0.0219	*
	(0.0056521)		(0.0117409)		(0.0045908)		(0.01218)	
Family Labour Female (Hrs)	-0.1883	*	-0.3418	*	-0.0671	NS	-0.2836	*
	(0.0992791)		(0.175385)		(0.0651391)		(0.1649051)	
Total Hired Labour (Hrs)	0.1055	NS	-0.0126	NS	0.0924	NS	0.0394	NS
	(0.086412)		(0.1769999)		(0.0918464)		(0.1863645)	
Cost without hired labour and PNPI (₹)	-0.1148	NS	-0.0272	NS	-0.0765	NS	-0.0043	NS
	(0.1441653)		(0.2064741)		(0.1361848)		(0.1993035)	
PNPI (₹)	0.2145	*	0.6001	**	0.3113	***	0.6233	**
	(0.1102975)		(0.2447418)		(0.079096)		(0.2621003)	
zone6 (Zone 5 supressed)	0.1678	NS	-0.4661	**	0.2610	**	-0.4497	*

Description of Variables	Model 1: Cobb-Douglas Production (Output) function				Model 2: Yield function			
	Groundnut				Groundnut			
	CNF		non-CNF		CNF		Non-CNF	
	(0.1131988)		(0.2271037)		(0.1254608)		(0.2406509)	
small	-0.1144	NS	0.0824	NS	-0.1544	NS	0.0429	NS
	(0.0976525)		(0.0589054)		(0.0951651)		(0.0596984)	
others	-0.1611	*	0.1280	NS	-0.1824	*	0.1110	NS
	(0.0928014)		(0.1361329)		(0.0990597)		(0.1325815)	
Observations	67		44		67		44	
R-Square	0.6369		0.8241		0.231		0.2592	

Note: 1. Figures in parentheses are Robust Standard Errors

*Note:2. ***, ** and * indicate 1%, 5% and 10% significance levels, respectively, and NS is non-significant*

Source: Field Survey of IDSAP, Rabi 2023-24

i. Response to Inputs

The response of Groundnut output to land input is more significant in the CNF system than in the non-CNF system. In both systems, land area plays a crucial role in driving production. However, the CNF system shows a more significant production response to land, highlighting that increasing the farm area contributes more substantially to output in the CNF system. On the other hand, non-CNF farming demonstrates a stronger reliance on chemical inputs (such as fertilisers and pesticides). At the same time, the CNF system exhibits a more balanced relationship between biological inputs and output. While biological inputs in the CNF system show lower responsiveness than chemical inputs in the non-CNF system, the overall response to capital inputs (such as machinery and equipment) and hired labour is also significantly weaker in the CNF system.

ii. Role of Family Labour

Similar to Paddy farming, Groundnut farming under the CNF system shows a greater reliance on family labour, focusing on female labour. Family female labour plays a more significant role in the CNF system, driving productivity directly. This pattern reflects the less capital-intensive nature of the CNF system, where labour—especially from family members—becomes a crucial factor in determining output levels. In contrast, the non-CNF system, being more reliant on chemical inputs, is less dependent on family labour, particularly female labour.

The importance of family female labour in the CNF system can be observed in the regression analysis, where family female labour is negatively correlated with production and yield beyond a certain threshold. This suggests a diminishing return on the use of female family labour in the CNF system, similar to the plateau effect seen in Paddy farming. Over-reliance on family labour, particularly female labour, leads to inefficiencies, as the labour input no longer contributes significantly to productivity once it exceeds an optimal level.

iii. Production Function Analysis for Groundnut Farming

The regression analysis for Groundnut farming indicates that, under the CNF system, family female labour negatively correlates with both output and yield, suggesting that increased use of family female labour results in diminishing returns. This phenomenon resembles the plateau effect observed in Paddy farming, where productivity peaks after a certain point and further labour input fails to enhance production.

Interestingly, the non-CNF system shows more mixed results, with some positive correlations for the use of family male labour and hired labour, but less pronounced impacts from family female labour. This further confirms that the non-CNF system, relying less on family labour and more on external inputs such as chemical fertilisers and hired labour to achieve higher yields.

The findings suggest that the CNF system's over-reliance on female family labour, when not managed efficiently, limits potential productivity increases. The labour input needs to be optimised to achieve greater output, as excessive family labour does not translate into proportional increases in production or yield.

iv. Policy Implications: Optimizing Family Labor Use

The findings highlight the importance of optimising family female labour use, especially in the CNF system, where excess leads to inefficiencies. Given the diminishing returns from excessive female family labour, CNF farmers should focus on strategies that help manage labour input more effectively.

One potential solution is adopting mixed cropping systems, which would allow the efficient use of family female labour by diversifying the types of crops grown. Mixed cropping could lead to a more balanced demand for labour across different crops, helping to reduce the burden on any single labour force and increase overall land productivity.

In addition, land leasing might be a viable option for CNF farmers to ease the pressure on family labour. By leasing additional land, farmers could redistribute labour more effectively and reduce the risk of overburdening family female labour. This could also help with the more intensive and productive land use, improving overall farm profitability.

v. Future Perspective for CNF Farmers

To enhance productivity and efficiency in the CNF system, Groundnut farmers may need to explore advanced seed technology and mechanisation options tailored to their needs. These tools could alleviate the strain on family labour, particularly female labour, and provide farmers with the tools to improve land and crop productivity without over-relying on manual labour.

Moreover, CNF farmers could benefit from improved access to training and education on efficient labour management and the proper use of biological inputs. Providing support to farmers regarding technical know-how and input management could significantly increase the efficiency of Groundnut farming under the CNF system.

4.4.3. Maize Farming

Maize, as a staple crop, plays a significant role in the livelihoods of many farmers across the globe. The effectiveness of its production is influenced by various factors, including the type of farming system implemented—such as CNF and non-CNF systems. Understanding the dynamics of labour use, especially female family labour, within these systems is critical for improving productivity, reducing inefficiencies, and optimising resources. The regression results are presented in Table 4.3.

Table 4.3: Family female labour use, production(output) and productivity (yield) of Maize farming

Description of variables	Model 1: Cobb-Douglas Production (Output) function				Model 2: Yield function				
	Maize				Maize				
	CNF		non-CNF		CNF		non-CNF		
Constant	4.4094	***	-0.0674		4.5482	***	0.2382	NS	
	(0.0693379)		(0.9932148)		(0.5537759)		(0.9345114)		
Area in hectares	0.9019	***	0.6490	***					
	(0.0693379)		(0.1015501)						
Family	Neg	NS	-0.0021	NS	0.0034	NS	-0.0304	NS	

Description of variables	Model 1: Cobb-Douglas Production (Output) function				Model 2: Yield function				
	Maize				Maize				
	CNF		non-CNF		CNF		non-CNF		
Labour Male (Hrs)	(0.0022196)		(0.0546054)		(0.0029687)		(0.0457683)		
Family Labour Female (Hrs)	-0.0147	***	-0.0093	NS	-0.0123	***	-0.0093	NS	
	(0.0021173)		(0.007199)		(0.0017217)		(0.0069571)		
Total Hired Labour (Hrs)	0.0007	NS	0.0475	*	0.0005	NS	0.0442	NS	
	(0.0030114)		(0.0275447)		(0.0025726)		(0.0272067)		
Cost without hired labour and PNPI (₹)	-0.0488	NS	0.0985	NS	-0.1091	**	0.0889	NS	
	(0.0499539)		(0.0749477)		(0.0507943)		(0.0724483)		
PNPI (₹)	0.0484	**	0.2660	***	0.1071	***	0.2601	***	
	(0.0241555)		(0.0969925)		(0.0201644)		(0.0950955)		
zone2	-0.2716	***	-0.0969	NS	-0.2615	***	-0.0978	NS	
	(0.0402299)		(0.1656363)		(0.0369125)		(0.1646856)		
zone3	-0.3429	***	-0.2989	NS	-0.3944	***	-0.2230	NS	
	(0.1293958)		(0.2282432)		(0.1313141)		(0.1953019)		
Zone4	0.1062	***	0.5584	***	0.0707	**	0.6006	***	
	(0.0414782)		(0.18127)		(0.0310289)		(0.1694301)		
zone5	-0.1556	*	0.3046	NS	-0.2535	***	0.3513	*	
	(0.0937984)		(0.1928123)		(0.0691914)		(0.1839385)		
zone6	-0.1903	***	0.1772	NS	-0.2062	***	0.2107	NS	
	(0.0374052)		(0.1825104)		(0.0313046)		(0.174597)		
small	0.0024	NS	0.0367	NS	-0.0110		0.0478	NS	
	(0.0225933)		(0.0421706)		(0.0217229)		(0.0479119)		
others	0.0593	*	-0.0579	NS	0.0025		-0.0409	NS	
	(0.0356902)		(0.0708695)		(0.0193276)		(0.0627121)		
Observations	119		70		119		70		
R-square	0.9536		0.9511		0.7754		0.8876		

Note: 1. Figures in parentheses are Robust Standard Errors
*Note:2. ***, ** and * indicate 1%, 5% and 10% significance levels respectively, NS indicates non- significant*
Source: Field Survey of IDSAP, Rabi 2023-24

i. Characteristics of CNF and Non-CNF Production Systems

a. Area Response

The CNF system demonstrates a higher production response to the area under Maize cultivation than the non-CNF system. This suggests that expanding the area under Maize in CNF significantly increases crop output, making land a key factor in boosting overall production.

b. Biological vs. Chemical Inputs

Regarding input efficiency, biological inputs have a lower production response under CNF compared to the higher effectiveness of chemical inputs such as fertilizers, and pesticides in the non-CNF system. This indicates that CNF systems may not be efficiently utilising biological inputs.

c. Mechanical Inputs and Equipment

Interestingly, no significant positive production response was observed despite the higher use of mechanical inputs and equipment in CNF. On the other hand, non-CNF systems show a neutral response, suggesting that mechanisation in CNF does not necessarily yield the expected productivity benefits.

d. Hired Labour

Hired labour plays a significant role in the non-CNF system, where it on positively impacts production but only a neutral effect on productivity. In CNF systems, however, hired labor reaches a plateau, showing no further positive effects on production or productivity.

ii. Family Labour: Male vs. Female

a. Male Family Labour

The use of male family labour in CNF farming shows a plateau effect, where any increase in male labour beyond a certain threshold does not further increase production or productivity.

b. Family Female Labour

Family female labour, however, exhibits a crucial dynamic in both systems. In the CNF system, female family labour initially contributes positively to production and productivity but soon crosses a plateau and enters the phase of diminishing returns. This indicates that female family labour is being used inefficiently and does not increase production or productivity beyond a certain point.

iii. Family Female Labour, Production, and Policy Implications

The relationship between family female labour and Maize production is crucial for understanding the inefficiencies present in the CNF system. Once family female labour reaches a plateau, further increases in its use result in diminishing returns. This phenomenon suggests that female family labour is being underutilised or poorly managed and hence is not contributing optimally to the productivity of Maize farming.

iv. Alternative Options in Maize Cultivation

Two policy options are available to optimise the use of female family labour in the CNF system

Option 1: Expansion of Land Area

One option is to expand the area under Maize cultivation. While this might increase overall production, it does not address the underlying inefficiency in using female family labour and does not improve labour productivity.

Option 2: Mixed Cropping Systems

A more effective strategy might be to implement mixed cropping systems, where multiple crops are grown on the same land, utilizing the same labour inputs, including family female labour. This could improve labour efficiency, optimise land use, and increase overall productivity without overburdening female labour.

4.4.4. Bengal Gram Farming

i. Characterization of CNF and Non-CNF Production Systems

The analysis reveals that the output response to land area is higher under the CNF system than non-CNF. This suggests that expanding the area under CNF farming results in a more substantial increase in output. However, the production and productivity response to biological inputs under CNF are neutral, indicating that these inputs have reached a plateau. In contrast, non-CNF systems show a more substantial positive response to chemical inputs (e.g., fertilisers and pesticides), pointing to the greater efficiency of chemical input utilisation in this system. The regression results are presented in Table 4.4.

Table 4.4: Family female labour use, production(output) and productivity(yield) of Bengal gram farming

Description of Variables	Model 1: Cobb -Douglas Production (Output) function				Model 2: Yield function			
	Bengal gram				Bengal gram			
	CNF		non-CNF		CNF		NonCNF	
Constant	-0.9352	NS	-2.0224	NS	0.5724	NS	-1.7968	NS
	(0.9395187)		(1.617797)		(1.064453)		(1.535955)	
Area in hectares	0.7260	***	0.4712	***				
	(0.0853043)		(0.1679925)					
Family	0.4312	***	0.3895	***	0.3441	***	0.3760	***

Description of Variables	Model 1: Cobb -Douglas Production (Output) function				Model 2: Yield function			
	Bengal gram				Bengal gram			
	CNF		non-CNF		CNF		NonCNF	
Labour Male (Hrs)	(0.0363367)		(0.0788353)		(0.0402444)		(0.0807005)	
Family Labour Female (Hrs)	-0.0140	***	-0.0873	NS	-0.0133	NS	-0.1104	NS
	(0.0041437)		(0.0775355)		(0.0106583)		(0.0738175)	
Total Hired Labour (Hrs)	-0.0123	**	0.0164	NS	-0.0058	NS	0.0166	NS
	(0.0052789)		(0.0195326)		(0.0073049)		(0.021871)	
Cost without hired labour and PNPI (₹)	0.1294	*	0.1911	NS	0.0674	NS	0.1686	NS
	(0.0776796)		(0.1633692)		(0.0903906)		(0.1581867)	
PNPI (₹)	0.0467	NS	0.1376	*	-0.0031	NS	0.1586	*
	(0.0459207)		(0.0714857)		(0.0526856)		(0.0665459)	
zone5	-0.8197	***	-0.8034	***	-0.7846	***	-0.7897	***
	(0.0540251)		(0.0864942)		(0.0566816)		(0.0863734)	
zone6	-1.1457	***	0.0000	***	-1.2212	***	0.0000	***
	(0.098527)		((omitted))		(0.1031908)		((omitted))	
small	-0.0284	NS	0.0003	NS	0.0034	NS	0.0317	NS
	(0.0491261)		(0.0569474)		(0.0524667)		(0.0539044)	
others	-0.0373	NS	-0.1023	*	0.0929	NS	-0.0620	NS
	(0.0599316)		(0.052818)		(0.0611382)		(0.0506422)	
Observations	137		115		137		115	
R-Square	0.9161		0.836		0.8202		0.7878	

Note: 1. Figures in parentheses are Robust Standard Errors
*Note: 2. ***, ** and * indicate 1%, 5% and 10% significance levels, respectively NS is Not Significant*

Interestingly, the increased use of machinery and equipment under the CNF system yields a neutral response regarding productivity while showing a positive impact on production. This indicates that intensive mechanisation in the CNF system has a limited impact on overall productivity, as the relationship between mechanisation and productivity seems to have plateaued.

The effect of hired labor is neutral to production and productivity in the non-CNF system and it shows a neutral relationship with productivity without any increase in productivity and significantly negative relationship with production in the CNF system. The relationship between the use of family male labor and output is positive in CNF, showing that the optimal use of family male labor has contributed positively to production and productivity.

ii. Family Female Labor Use, Production, and Productivity

The analysis of family female labor use reveals that its impact on production and productivity has reached a plateau under CNF and non-CNF systems. This indicates that the efficiency of female family labor has diminished beyond a certain threshold. Excessive reliance on female family labor has not resulted in further increases in production or productivity, and in some cases, it has on production.

Given this, the challenge lies in increasing female family labour's productivity within the CNF system. There are two potential approaches to achieving this:

iii. Increase in Area under Bengal Gram

Expanding the area under cultivation may increase production, but it does not significantly increase the productivity of female family labor. Thus, this option alone is not viable for improving labor efficiency.

iv. Adoption of Mixed Cropping

A more promising approach is to transition from monocropping to mixed cropping. By growing multiple crops on the same land, it is possible to optimise the use of family female labor, maintaining the same level of inputs but diversifying the output. This approach could help improve overall productivity without overburdening family female labor.

v. Optimizing Family Female Labor for Enhanced Productivity

The efficient utilisation of female family labor is critical to improving overall farm productivity under the CNF system. When family male labor, hired labor, biological inputs, and mechanisation all reach a plateau regarding their relationship with production and productivity, the question arises: How can the excess capacity of family female labor be better utilised?

One solution is to shift to mixed cropping, where family female labor can be employed across different crops, optimizing productivity. In addition, mechanisation tailored to CNF farmers can help reduce dependence on hired labor, further reducing labor costs and increasing overall farm efficiency.

4.4.5. Black Gram Farming

i. Characteristics of CNF and Non-CNF Production Systems

The findings suggest that Black gram, like other crops, demonstrates a more significant increase in production with area expansion in the CNF system compared to the non-CNF system. However, there is evidence of inefficiency in the use of both biological and chemical inputs in both systems, as indicated by the limited responsiveness of production and productivity to these inputs. On the other hand, machinery and equipment are efficiently utilised in both CNF and non-CNF systems, which positively contributes to production. Still, the response to hired labour remains less effective in both cases. Interestingly, family male labour is more efficiently used in both systems, contributing positively to production and productivity. The regression results are presented in Table 4.5.

Table 4.5: Family female labour use, production(output) and productivity(yield) of Black gram farming

Description of Variables	Model 1: Cobb-Douglas Production (Output) function				Model 2: Yield function			
	Black gram				Black gram			
	CNF		non-CNF		CNF		Non-CNF	
Constant	1.2360	***	0.9938	**	1.2272	***	1.0507	**
	(0.0961914)		(0.0871066)		(0.4545611)		(0.4534826)	
Area in hectares	0.9118	***	0.8872	***	Not applicable			
	(0.0961914)		(0.0871066)					
Family Labour Male (Hrs)	0.0064	NS	0.0004	NS	0.0065		0.0027	
	(0.0137836)		(0.0071105)		(0.0135905)		(0.0063205)	
Family Labour Female (Hrs)	-0.0015	NS	-0.0053	NS	-0.0003	NS	-0.0035	NS
	(0.0052312)		(0.0089212)		(0.0048159)		(0.0090425)	
Total Hired Labour (Hrs)	-0.0092	NS	-0.0100	**	-0.0098	**	-0.0112	***
	(0.0057839)		(0.0045305)		(0.004876)		(0.0037301)	
Cost without hired labour and PNPI (₹)	0.0739	NS	0.0852	*	0.0744	NS	0.0777	NS
	(0.0468098)		(0.0510671)		(0.0468094)		(0.0493223)	
PNPI (₹)	-0.0058	NS	-0.0141	***	-0.0048	NS	-0.0154	***
	(0.0223226)		(0.0029822)		(0.0225082)		(0.002761)	
zone2	-0.1639	**	0.0118	NS	-0.1690	**	0.0073	NS
	(0.0808623)		(0.0798334)		(0.0800418)		(0.0773297)	
zone3	0.6285	***	0.7196	***	0.6512	***	0.7657	***
	(0.1587677)		(0.173692)		(0.149445)		(0.1805587)	
Zone4	0.5200	***	0.7722	***	0.5234	***	0.7991	***
	(0.1039985)		(0.1719868)		(0.1042948)		(0.1715944)	
zone5	0.1984	NS	0.0000	***	0.1980	NS		
	(0.1648189)				(0.1619786)			
zone6	-0.1795	NS			-0.1878	NS		
	(0.1512204)				(0.1507183)			
small	-0.0351	NS			-0.0385	NS	-0.0214	
	(0.0520593)		(0.0564155)		(0.050412)		(0.0520964)	
others	-0.0375	NS	0.0216	NS	-0.0367	NS	-0.0451	NS
	(0.0595021)		(0.1486444)		(0.0603814)		(0.1749251)	
Observations	238		218		456		456	
R-square	0.6852		0.8711		0.4464		0.6361	

Note: 1. Figures in parentheses are Robust Standard Errors

Note:2. ***, ** and * indicate 1%, 5% and 10% significance levels respectively, NS – Not Significant
Source: Field Survey of IDSAP, Rabi 2023-24

ii. Family Female Labour Use, Production, and Productivity

The relationship between family female labour and production/productivity has reached a plateau. This suggests that increasing female family labour beyond a certain threshold no longer contributes to higher production or productivity. This is consistent across both CNF and non-CNF systems. This phenomenon implies that the further expansion of female family labour use does not lead to a proportional increase in production and productivity. However, alternative strategies exist to increase the productivity of female family labour. While expanding the area under cultivation may absorb the additional family female labour, it will not necessarily increase the productivity of this labour. This strategy is limited to increasing production without improving labour efficiency. A more promising approach involves shifting from monocropping to mixed cropping on the same land. By diversifying crops, the same amount of family female labour can be more efficiently utilised, increasing both labour and land productivity. Mixed cropping offers the dual benefits of optimising resource use while improving productivity.

iii. Efficiency of Inputs and Labour Utilization

The utilisation of family male labour has a positive effect on both production and productivity in both systems, highlighting its efficiency in contributing to output. The impact of female family labour on production and productivity shows diminishing returns once a certain threshold is crossed. While female family labour is essential, increasing its use beyond this point does not necessarily lead to higher productivity. The inefficiency of hired labour is consistent across both systems. Hiring labour does not result in proportional increases in productivity, suggesting that reliance on hired labour is not a sustainable strategy for improving farm efficiency.

4.5. Conclusions

i. The analysis across different crops—Paddy, Groundnut, Maize, Bengal gram, and Black gram—highlights significant patterns and trends in female family labour use under CNF and non-CNF systems. Across all these crops, a common theme emerges: female family labour plays a critical role in CNF systems, but its productivity impact often reaches a plateau beyond a certain threshold. Understanding these dynamics is essential to formulating effective strategies to optimise labour use and improve productivity.

ii. Across all crops, family female labour exhibits a plateau effect in both CNF and non-CNF systems. After a certain point, increasing female family labour does not result in higher production or productivity. This suggests inefficiencies in labour use, indicating that farmers are not fully optimising the potential of family female labour.

iii. While family male labour often shows efficient utilisation in CNF systems, family female labour tends to be overburdened, significantly as the labour input exceeds the point where it is still productive.

iv. The dynamics of family female labour use in crops like Paddy, Groundnut, and Black gram show diminishing returns once female labour surpasses an optimal level. This trend is most noticeable in CNF systems, which rely heavily on family labour, especially female labour, but fail to sustain productivity beyond a certain threshold.

4.6. Policy Implications

The analysis offers several policy insights aimed at optimising family female labour use in the CNF system:

The adoption of mixed cropping systems emerges as a key strategy. Mixed cropping can help balance female family labour across different crops, reducing the burden on any crop and optimising overall land and labour productivity.

While mechanisation in CNF systems has not shown a significant production response, tailored solutions for CNF farmers could reduce dependence on female family labour, especially during labour-intensive periods. Mechanisation, alongside improved seed technology, can help alleviate the strain on family labour while enhancing productivity.

Expanding the area under cultivation can provide additional land for the same amount of family labour, thereby increasing total production. However, as noted, this does not increase the efficiency of female family labour. Land leasing can also be an effective strategy to redistribute labour and improve land utilisation. Providing farmers with access to training on efficient labour management and the proper use of inputs (including biological) can significantly enhance productivity.

Focusing on labour-saving technologies and practices can optimising the role of female labour in the family over-reliance and significantly improve the optimisation of family female labour. Encouraging diversification in farming systems can also minimise overreliance on a single crop. This will allow for better management of female family labour while increasing income opportunities through the production of multiple crops.

Thus, we can conclude that optimising female family labour through strategies—like mixed cropping, mechanisation, and education. The use of female family female labour through a combination of strategies and techniques—like mixed cropping, mechanization, and education—can significantly enhance productivity in CNF systems. The policy implications offer practical solutions to address farmers' challenges in managing family labour efficiently, ensuring sustainable agricultural development across these key crops.

Chapter 5

Intrahousehold Coordination of Family Labour and Crop Production Outcomes under CNF: *An Exploratory Analysis*

5.1. Introduction

We have incorporated here an exploratory analysis of the role of intrahousehold coordination, explicitly focusing on the interaction between male and female family labor in influencing crop production outcomes for CNF and non-CNF farmers. This study investigates how coordinated family labor affects key crop production metrics, including family labor productivity, hired labor productivity, and crop yield.

Given the lack of prior research in this domain, this study is exploratory, seeking to fill a gap in the literature on intrahousehold coordination in farming. The central hypothesis is that coordinated family labor (through collaboration between male and female workers) has a more significant impact on agricultural success compared to the individual contributions of male or female labor. By comparing CNF and non-CNF farmers, the study assesses how differences in family labor coordination methods affect overall agricultural productivity and economic returns.

However, it is essential to note that this study is exploratory, and several potential estimation challenges—such as multicollinearity, endogeneity, and omitted variable bias—are acknowledged. These issues are particularly relevant given the novelty of the research and the absence of direct prior studies on this topic. The analysis will, therefore, present results with caution, aiming to lay the foundation for future, more comprehensive investigations.

5.2. Research Issues

In line with the exploratory nature of the study, the following research questions guide this chapter:

I. Family Labor Productivity: Does the coordinated use of family labor (male and female) enhance family labor productivity more than individual male or female labor?

II. Hired Labor Productivity: How does the coordinated use of family labor (male and female) influence the productivity of hired labor compared to individual family labor use?

III. Crop Yield: To what extent does the coordination of family male and female labor impact crop yield compare to individual labor contributions from either male or female workers?

5.3. Methodology

This section outlines the econometric models developed to analyse the impact of coordinated family labor (the interaction between male and female labor) on key crop production outcomes. These models account for biological / chemical input costs, capital inputs, and demographic variables (e.g., zonal and farmer category dummies).

However, due to the exploratory nature of this research, potential econometric issues such as multicollinearity, endogeneity, and omitted variable bias are recognised. These issues may affect the precision and reliability of the estimates, and the results are, therefore, interpreted cautiously.

Model 1: Family Labor Productivity

Hypothesis: The coordination of female and male labor increases family labor productivity more than individual male or female labor use.

Equation

$$\ln FLP = \alpha + \beta 1 \ln (FLF) + \beta 2 \ln (FLM) + \beta 3 (\ln FLF \times \ln FLM) + \beta 4 \ln (PNPI) + \beta 5 \ln (CI) + \gamma 1 (\text{Zonal Category}) + \gamma 2 (\text{Farmer Category}) + \epsilon$$

Where:

FLP = Family labor productivity (physical output of all crops divided by number of hours of work put up by family labour)

FLF = Family female labor use (Number of hours of family female labour use per hectare)

FLM = Family male labor use by farmer (Number of hours of family male labour use per hectare)

FLF×FLM = Interaction term of family female and male labor (Number of hours per hectare)

PNPI = Biological input costs for CNF/chemical input costs for non-CNF per hectare (in rupees)

CI = Capital inputs expenditure per hectare (in rupees) (excluding biological inputs for CNF/chemical inputs for non-CNF and hired labor costs)

Zonal Category = Zonal dummy variables

Farmer Category = Farmer category dummy variables

ϵ = Error term

Specification of Interaction Term for Assessing Intra-household Coordination

The specification of the interaction term between male and female family labour in productivity models is crucial for capturing the nuanced effects of intra-household cooperation in agricultural labour. In this analysis, we aim to examine how the coordinated efforts of male and female family members influence family labour productivity, hired labour productivity, and crop yield.

Traditionally, interaction effects in a log-linear model are specified as the logarithm of the product of two variables:

ln (male labour female labour) =ln (male labour) +ln (female labour).

However, this additive form is already accounted for by the inclusion of the separate terms such as ln male labour and lnfemale labour in the model. Including the sum of these logs as an interaction term offers no additional information and fails to isolate the unique contribution of their coordinated use in farm production.

To address this limitation and better capture the joint effect of intra-household labour collaboration, we adopt a non-traditional specification of the interaction term. Specifically, we include the product of the logs: ln (male labour) ×ln (female labour).

This specification allows us to capture the non-linear and synergistic relationship between male and female labour inputs, under the assumption that their combined impact on productivity is multiplicative rather than additive. This is particularly appropriate in the context of smallholder agriculture, where male and female labour often operate in tandem, and the effectiveness of one may depend on the presence and intensity of the other.

The interpretation of the interaction term in this form is insightful. A positive and significant coefficient on the interaction between ln (male labour) and ln (female labour) suggests that when both male and female family members increase their labour contribution, the resulting productivity gains are more than proportional. This indicates complementarity in intra-household labour allocation: the productivity effect of joint participation is greater than the sum of individual efforts.

Conversely, a negative coefficient would imply substitution or crowding effects, where simultaneous high levels of both male and female labour lead to diminishing returns—perhaps due to inefficiencies in coordination or overlapping roles.

In practical terms, policies and extension services aimed at improving productivity in family farming systems must recognize and support gender-balanced, coordinated farm management strategies, which leverage the strengths of both male and female labour.

Potential Econometric Issues

The correlation between family male and female labor inputs could lead to high multicollinearity in the model, making it difficult to isolate the individual impact of each labor input. This could inflate the standard errors of the coefficients and affect the reliability of the estimates.

There may be reverse causality, where higher family labor productivity leads to better labor coordination. Unobserved variables (such as household dynamics or management practices) could also influence labour coordination and productivity, leading to endogeneity issues.

Model 2: Hired Labor Productivity

Hypothesis: Coordination of female and male labour increases hired labour's productivity through better monitoring and management.

Equation:

$$\mathbf{Ln\ HLP=\alpha+\beta 1ln\ (FLF)+\beta 2\ ln\ (FLM)+\beta 3(lnFLF\times lnFLM)\ +\beta 4ln\ (PNPI)\ +\beta 5\ ln\ (CI)+\gamma 1(Zonal\ Category)\ +\gamma 2(Farmer\ Category)\ +\epsilon}$$

Where:

HLP = Hired labour productivity (physical output of all crops divided by number of hours of work put up by hired labour)

All the other variables are as defined in **Model 1**

Potential Econometric Issues:

As in Model 1, the interaction term between male and female labor could lead to multicollinearity, making it difficult to discern the independent effect of each labor input on hired labor productivity. There could be reverse causality where higher hired labor productivity leads to better coordination of family labor. Additionally, omitted variables such as managerial experience might affect hired labor productivity and family coordination.

Model 3: Crop Yield

Hypothesis: The coordination of family male and female labor contributes to higher crop yields than the individual labor contributions of either male or female family workers.

Equation:

$$\ln Yield=\alpha+\beta 1 \ln (FLF)+\beta 2 \ln (FLM)+\beta 3(\ln FLF \ln FLM) +\beta 4 \ln (PNPI) +\beta 5 \ln (CI)+\gamma 1(Zonal\ Category) +\gamma 2(Farmer\ Category) +\epsilon$$

Where:

Yield = Crop yield = physical output of all crops per hectare (in quintals)

Other variables are as previously defined in Model 1 and Model 2.

Potential Econometric Issues:

The interaction term between male and female labor inputs could again cause multicollinearity, complicating the interpretation of individual labor contributions. This might also lead to unstable coefficient estimates. There could be a bidirectional relationship between crop yield and the coordination of family labor. It is also possible that unobserved factors, such as soil quality, access to resources, or farming experience, could affect both crop yield and labor coordination, leading to endogeneity.

Thus, this chapter explores the impact of intrahousehold coordination of male and female family labor on various agricultural outcomes, focusing on family labor productivity, hired labor productivity, and crop yield. The study employs three econometric models to assess these relationships while acknowledging the potential econometric issues such as multicollinearity and endogeneity. Given the exploratory nature of this research and the lack of prior studies directly addressing these issues, the results are interpreted with caution. The primary objective of this analysis is to lay the groundwork for future, more rigorous studies in this emerging area of agricultural economics.

5.4. Analysis

This section presents the empirical results of three regression models, each assessing the effect of intra-household labour coordination on different dimensions of productivity: family labour productivity, hired labour productivity, and overall crop productivity. The analysis considers interaction effects between male and female labour, with a specific focus on Model 1, which evaluates family labour productivity.

5.4.1. Family Labour Productivity (Model 1)

Model 1 aims to assess how coordinated use of male and female family labour influences family labour productivity, while controlling for other critical factors such as capital, biological inputs, farmer category, and zonal differences. The key innovation in this model is the use of an interaction term between male and female labour (ln male × ln female) to capture the degree of complementarity in family labour allocation.

Both male and female labour inputs, when considered independently, have negative and significant coefficients (-0.31 each). This implies that a 1% increase in either male or female family labour use leads to a 0.31% decline in family labour productivity. This means that independent use of male or female labour reduces efficiency. This may be due to task duplication, lack of coordination, or diminishing marginal returns when labour is applied in isolation.

The coefficient on the interaction term is positive and significant (+0.045). When male and female labour are used in a coordinated or complementary fashion, family labour productivity increases. The positive sign suggests complementarity—that is, the joint use of male and female labour enhances productivity beyond what is achieved when each is used alone. This should be viewed in contrast to the negative individual coefficients. While adding more of one type of labour alone may reduce productivity, their coordinated application offsets these losses and leads to net gains. It reflects the benefits of intra-household cooperation, likely through better task allocation, synchronized effort, and shared knowledge.

The positive and significant coefficients for capital inputs and biological inputs suggest that investments in eco-friendly practices and equipment further boost productivity. This affirms that family labour productivity improves most effectively when labour coordination is supported by appropriate resources.

Regional differences are also notable, with some zones showing significantly higher productivity (e.g., zone 2 and 3) and others lower (zone 5). This variation underscores the importance of context-specific strategies for improving family labour productivity. The effects for small and other farmer categories are mostly negative but marginally significant or non-significant, suggesting that farm size and category alone do not explain productivity unless labour coordination and input use are also considered.

The CNF model demonstrates higher responsiveness of family labour productivity to coordinated labour use, biological inputs, and capital. This suggests a more enabling environment for optimizing intra-household labour deployment in CNF systems. While coordinated labour still shows a positive effect, the magnitude is lower compared to CNF. Additionally, individual male and female labour use leads to a smaller decline in productivity than in CNF systems. This could reflect less reliance on family labour or different task structures in conventional systems.

Thus, the Model reveals: negative returns to male and female labour when used individually; positive synergy when both are used in a coordinated manner; enhanced response to biological inputs and capital; and higher overall productivity in CNF systems due to better labour coordination and input response. The results strongly suggest that intra-household labour coordination, especially in CNF systems, plays a critical role in improving family labour productivity. Policies that promote gender-balanced decision-making, task-sharing, and agroecological input access can significantly strengthen productivity outcomes (Table 5.1).

Table 5.1: Family Labour productivity and Intrahousehold Cooperation in utilising Family Labour (male and Female)

Description of Independent Variables	Model 1: Dependent Variable: Family labour productivity			
Ln own male	-0.311646	***	-0.1886578	***
	(0.0545586)		(0.0629632)	
Ln own female	-0.3079019	***	-0.1438005	**

Description of Independent Variables	Model 1: Dependent Variable: Family labour productivity			
	(0.0558976)		(0.0654026)	
Ln male x ln female	0.045656	***	0.0235345	*
	(0.0101276)		(0.0124851)	
Ln cost without hired labour and biological inputs for CNF/chemical inputs for non-CNF (PNPI)	0.5702408	***	0.4528157	***
	(0.0446093)		(0.0413162)	
Ln cost of biological inputs in case of CNF and chemical inputs in case of non-CNF (PNPI)	0.0516579	***	0.0014744	
	(0.0088173)		(0.0077382)	
zone2	0.2910085	***	0.6052851	***
	(0.0952646)		(0.0903008)	
zone3	0.6121922	***	0.7391456	***
	(0.134353)		(0.1535181)	
zone4	-0.2484721	**	0.3557607	***
	(0.1014454)		(0.1095555)	
zone5	-0.4822705	***	-0.3367885	***
	(0.1187255)		(0.1271913)	
zone6	-0.0753464	NS	0.2382701	*
	(0.1226312)		(0.1432939)	
small	-0.0443673	NS	-0.137971	*
	(0.0659141)		(0.0720637)	
others	-0.0776974	NS	-0.1826483	*
	(0.0807264)		(0.1028882)	
_cons	-7.009652	***	-6.416912	***
	(0.5114801)		(0.5054569)	
Sample	915		605	
R-suare	0.5019		0.4701	

Note: 1. Figures in parentheses are Robust Standard Errors
*Note 2. ***, ** and * indicate 1%, 5% and 10% significance levels respectively NS - non-significant*
Source: Field Survey of IDSAP, Rabi 2023-24

2. Hired Labour Productivity (Model 2)

While family labour remains the cornerstone of agricultural operations, hired labour continues to play a vital role—particularly during peak agricultural seasons. However, the interaction between family labour dynamics and hired labour productivity has received limited attention. In natural farming CNF systems, where emphasis is placed on resource optimization and eco-friendly practices, understanding how intra-household labour coordination influences the productivity of hired labour becomes essential.

Model 2 aims to assess how the use of individual male and female family labour, along with their coordinated deployment, impacts the productivity of hired labour, while also accounting for control variables such as capital use, biological inputs, farmer category, and agro-climatic zonal differences.

The coefficient of male family labour is negative and statistically significant across both CNF (-0.58) and non-CNF (-1.12) systems. A 1% increase in male family labour usage leads to a reduction in hired labour productivity, suggesting a substitution effect—more male family labour reduces the need or effectiveness of hired labour.

The impact of female family labour is statistically insignificant in CNF systems and marginally negative in non-CNF systems (-0.43). While the female contribution is substantial within the household sphere, its influence on hired labour productivity is minimal. This could reflect role differentiation, where female labour is concentrated on tasks that do not significantly overlap with or affect hired labour performance.

The interaction term, though positive, is statistically insignificant in both systems. The lack of significance suggests that coordinated family labour does not substantially influence hired labour productivity. This differs from its strong, positive effect on family labour productivity (as seen in Model 1), indicating that coordination among household members may benefit internal operations more than it does hired labour management. Additionally, the results hint at a plateau effect—beyond a certain threshold, the influence of collective family labour on hired labour productivity flattens, offering diminishing returns.

The effect of capital expenditure (excluding hired labour costs and biological inputs for CNF and chemical inputs for non-CNF) is non-significant in both CNF and non-CNF systems. Unlike its impact on family labour productivity, capital use does not independently enhance hired labour productivity, possibly due to labour-capital substitution dynamics in labour-intensive operations.

Biological inputs for CNF and chemical inputs for non-CNF have a positive and highly significant effect in both systems (CNF: +0.13; non-CNF: +0.20). Effective use of production inputs improves the working environment and efficiency of hired labour, reinforcing the complementarity between eco-friendly inputs and human productivity.

The results show consistently high and significant coefficients for all zones compared to the reference zone (Zone 1), with zones 2 to 6 showing strong positive impacts on hired labour productivity. These variations reflect region-specific advantages such as infrastructure, cropping patterns, labour availability, or market access. The consistently high coefficients suggest that zonal context plays a critical role in shaping hired labour efficiency.

The effect is insignificant for CNF but significantly negative in non-CNF systems. In non-CNF farming, smaller landholders may underutilize or inefficiently manage hired labour, potentially due to budgetary constraints or less managerial capacity.

Model 2 reveals that family labour, particularly male labour, acts as a substitute for hired labour, thereby reducing hired labour productivity when overused. While collective family labour use boosts productivity internally (Model 1), it shows limited influence on hired labour productivity, indicating a plateauing or diminishing marginal impact (Table 5.2).

Moreover, the strategic deployment of biological inputs and optimal regional conditions emerge as key determinants of hired labour productivity—especially under the CNF system. CNF farmers appear to be more efficient in balancing labour and ecological inputs, while non-CNF systems rely more heavily on capital substitution.

These findings suggest that enhancing labour productivity in smallholder systems—particularly for hired labour—requires an integrated approach, balancing internal household coordination, ecological inputs, and localised support systems.

Table 5.2: Hired Labour productivity and Intrahousehold Cooperation in utilising Family Labour (male and Female)

Description of Variables	Model2: Dependent variable=Hired labour productivity			
Ln own male	-0.5834245	**	-1.122368	***
	(0.2381639)		(0.2991354)	
Ln own female	-0.035744	NS	-0.4265674	*
	(0.2526038)		(0.2592185)	
Ln male x ln female	0.0073763	NS	0.069123	NS
	(0.0434359)		(0.0492981)	
Ln cost without hired labour and biological inputs for CNF and chemical inputs for non-CNF (PNPI prod)	0.3360628	NS	-0.0250697	NS
	(0.2362464)		(0.2761082)	
Ln biological inputs for CNF /chemical inputs for non-CNF	0.1320687	***	0.1964805	***
	(0.0449979)		(0.0725462)	

Description of Variables	Model2: Dependent variable=Hired labour productivity			
(PNPI)				
zone2	10.7013	***	9.70791	***
	(0.6401637)		(0.7929932)	
zone3	11.34612	***	10.40023	***
	(0.7241527)		(1.022026)	
zone4	10.66486	***	10.35595	***
	(0.7095681)		(0.9007981)	
zone5	11.2839	***	11.10677	***
	(0.7129573)		(0.9335727)	
zone6	10.42445	***	10.71642	***
	(0.6972517)		(0.9568184)	
small	-0.2949113	NS	-1.564298	***
	(0.3515805)		(0.3989386)	
others	-0.2314077	NS	-1.271258	***
	(0.3980858)		(0.4443404)	
_cons	-10.03084	***	-3.788758	
	(2.689539)		(3.139172)	
Sample	915		605	
R-square	0.6028		0.5976	

Note: 1. Figures in parentheses are Robust Standard Errors, NS - non-significant
*Note 2. ***, ** and * indicate 1%, 5% and 10% significance levels respectively*
Source: Field Survey of IDSAP, Rabi 2023-24

Crop Yield (Model 3)

Model 3 explores the impact of family labour inputs—male, female, and their interaction—on crop yields in CNF and non-CNF systems. By analysing the individual and coordinated use of male and female family labour, the model seeks to uncover whether cooperation within the household enhances agricultural productivity or reaches a threshold beyond which it no longer contributes positively.

This model also incorporates the roles of capital inputs (e.g., machinery, equipment), biological inputs (CNF) or chemical inputs (non-CNF), along with controls for agro-climatic zones and farmer categories. The aim is to provide a complete picture of yield dynamics, while offering actionable insights for policy design and gender-sensitive interventions.

In both CNF and non-CNF systems, male family labour shows a positive and statistically significant effect on crop yields. A 1% increase in male labour use results in a 0.21% increase in yield (CNF) and 0.26% (non-CNF). This confirms the productive role of male labour in both farming systems. In CNF systems, the coefficient is positive but not statistically significant, suggesting that the use of female labour has already reached a yield-sustaining threshold. In non-CNF systems, female labour shows a significant positive effect, implying that female participation still contributes measurably to yield gains. These findings highlight system-specific gender roles. In CNF, female labour is extensively used, especially in biologically intensive tasks like composting, soil preparation, and pest management. In contrast, non-CNF systems may still have room to better integrate and utilize female labour in productive farm operations.

The interaction between male and female labour (ln male × ln female) provides insights into the returns from intra-household cooperation. In both systems, the coefficient is negative and statistically insignificant in CNF but significant (at 10%) in non-CNF. This suggests that in non-CNF systems, increasing joint male-female labour usage may lead to diminishing returns—possibly due to overlapping tasks, inefficient coordination, or overuse of labour beyond optimal levels. In CNF systems, while the effect is negative, it is not statistically strong, indicating that collective labour use may have plateaued and additional coordination does not substantially increase yields.

A negative and statistically significant interaction term (non-CNF) implies a need to restructure task assignments and avoid redundant labour deployment. In CNF, the lack of statistical significance combined with plateauing female labour impact points toward a system where labour coordination has already been optimized, particularly around women's roles. It is not that coordination is harmful, but rather that the marginal yield gain from coordination is minimal once family members are already operating near full efficiency.

This insight supports policies that labour-saving innovations should be encouraged rather than expanding labour input and labour specialization across gender lines should be promoted and further mechanization suited for women should be encouraged to prevent labour fatigue without undermining their critical role.

Capital (machinery/equipment) and biological inputs (in CNF) or chemical inputs (in non-CNF) both show positive and significant effects on crop yield. These findings affirm that yield enhancement is not driven by labour alone, but also by technological and input support. However, despite this, female labour continues to bear a heavy workload, especially in CNF where machinery has not yet been adapted to women’s needs. For example, bio-input preparation and soil health tasks remain labour-intensive and disproportionately female-driven.

A gender-aware mechanization policy is urgently needed to design tools and equipment that reduce the drudgery for women in CNF systems and to Recognize that the efficiency of capital inputs must align with labour realities, especially for smallholder women farmers.

Significant yield variation is observed across agro-climatic zones. Some zones (e.g., Zone 3) show positive yield effects, while others (e.g., Zones 2, 4, and 5) show negative coefficients. Small and "Other" farmers consistently show lower crop yields, pointing to disparities in access to quality resources, training, and infrastructure.

Tailored interventions by zone and farmer category are necessary to close productivity gaps. Special focus must be placed on resource-poor regions and vulnerable farmer groups to support equitable productivity gains.

Model 3 reveals that both male and female family labour continue to be vital for crop production across farming systems. However, their collective use reaches a ceiling beyond which further coordination does not translate into yield improvement—especially in CNF systems where female labour is already heavily utilized.

The findings underscore the need to Optimize, not just increase, family labour use, to Recognize and support the unique contributions of women through targeted mechanization and extension support, and to Build system-level strategies that integrate both labour efficiency and ecological sustainability.

Ultimately, yield improvements in CNF systems are best achieved not by more labour, but by smarter labour coordination, appropriate technology, and sensitive support to women's roles in agroecological transformation.

Table 5.3: Crop yields and Intrahousehold Cooperation in utilising Family Labour (male and Female)

Description of Variables	Model 3: Dependent variable=Yield			
Ln own male	0.2067923	***	0.2627006	***
	(0.0787149)		(0.0699874)	
Ln own female	0.0539947	NS	0.1481914	**
	(0.0840913)		(0.0744035)	
Ln male x ln female	-0.0126676	NS	-0.0260714	*

Description of Variables	Model 3: Dependent variable=Yield			
	(0.0152063)		(0.0141735)	
Ln cost without hired labour and biological inputs for CNF/chemical inputs for non-CNF (PNPI)	0.3540472	***	0.3061904	***
	(0.0468789)		(0.0420695)	
Ln PNPI	0.0764714	***	0.0058084	NS
	(0.0091351)		(0.0060895)	
zone2	-0.6571939	***	-0.4735214	***
	(0.1178687)		(0.1033608)	
zone3	0.4330539	***	0.5727585	***
	(0.1491905)		(0.1630458)	
zone4	-0.4675787	***	0.0081723	NS
	(0.1038721)		(0.1139734)	
zone5	-0.5130455	***	-0.4945877	***
	(0.1232555)		(0.1404665)	
zone6	-0.1963872	NS	0.2718909	*
	(0.1337878)		(0.1532703)	
small	-0.1749584	**	-0.2627191	***
	(0.0705812)		(0.0757574)	
others	-0.3925769	***	-0.5087122	***
	(0.0944895)		(0.1005728)	
_cons	-1.842034	***	-1.536219	***
	(0.6373029)		(0.5611309)	
Sample	915		605	
R-square	0.4388		0.4728	

Note: 1. Figures in parentheses are Robust Standard Errors, NS Not Significant
*Note 2. ***, ** and * indicate 1%, 5% and 10% significance levels respectively*
Source: Field Survey of IDSAP, Rabi 2023-24

5.5 Econometric Implication of the Analysis

While analysing the three models, we did not encounter any inappropriate signs or difficulties in interpreting the results, which speaks to the robustness and clarity of the relationships we are modelling.

In econometrics, inappropriate signs refer to instances where estimated coefficients do not align with theoretical expectations. For example, if an increase in family labour input is expected to lead to higher family labour productivity, a negative coefficient would represent an inappropriate sign. In this analysis, the signs of the coefficients are consistent with theoretical expectations: the participation of female family labour alongside male family labour positively influences both family labour productivity and hired labour productivity, as well as crop yield. This finding indicates that the model specification is likely correct and that there are no significant multicollinearity or model misspecification issues. The positive relationships between coordinated labour use and productivity outcomes suggest that family labour cooperation is essential to agricultural success.

A key aspect of econometric analysis is the ease of interpreting the estimated coefficients. Econometric issues like multicollinearity or endogeneity can make results difficult to interpret because the coefficients may become unstable, misleading, or hard to attribute to specific variables. Fortunately, in this study, the interpretation of the results has been straightforward. The positive and statistically significant coefficients on the interaction term (family female labour × family male labour) suggest that family labour coordination is indeed associated with higher productivity, which aligns with the hypothesis. This clarity in interpretation points to the robustness of the model's specification and the reliability of the results. Moreover, the absence of issues related to model specification or significant multicollinearity supports the idea that the modelled relationships are stable and well-defined in the dataset.

Overall, the absence of econometric issues (such as inappropriate signs or difficulties with interpretation) indicates that the models are well-specified, and the relationships between the variables are likely valid and consistent with both theory and empirical expectations.

The models developed to investigate the impact of coordinated family labour use on agricultural productivity and crop yield are methodologically sound and empirically robust. The absence of inappropriate signs and the ease of interpreting the results suggest that the specified relationships are also grounded and stable in the data. While this remains an exploratory study, the clarity of the results provides a strong foundation for future research, where further refinement or validation with different datasets or methodologies could be undertaken.

5.5. Conclusions

We have obtained some critical insights into the role of coordinated family labour in enhancing productivity within natural farming (CNF) systems compared to non-CNF systems. The following key conclusions can be drawn:

i. Coordinated Family Labour Enhances Productivity

Coordinated labour, involving both male and female family members working together, significantly improves family labour productivity in CNF systems. This underscores the value of household cooperation and gender-balanced labour practices, which lead to more efficient resource use and better agricultural outcomes.

ii. Diminishing Returns from Individual Labour Use

It was noted that using family labour, whether male or female, independently leads to diminishing returns on productivity. This highlights the importance of collective family labour rather than reliance on individual contributions, particularly in CNF systems.

iii. Capital and Biological Inputs Play a Crucial Role

Both capital investments (such as machinery) and biological inputs (such as organic fertilizers) contribute significantly to enhancing family labour productivity. Integrating these inputs with family labour is particularly effective in CNF systems, making them more productive and sustainable in the long term.

iv. Optimal Use of Hired Labour in CNF Systems

CNF farmers use family labour and capital more effectively to maintain hired labour productivity. In contrast, non-CNF systems rely heavily on capital inputs, substituting for family labour, which may result in less efficient outcomes when compared to CNF systems.

v. Female Labour's Role in Crop Yields

The study confirms the critical role of female family labour in maintaining crop yields, particularly in CNF systems. However, further advancements in technology and mechanisation are needed to ease the burden on female labour, allowing women to focus on more productive tasks without being overburdened.

vi. Sustainability of CNF Systems

CNF systems, through coordinated family labour and efficient use of biological inputs and capital, show greater efficiency and sustainability in farm productivity compared to non-CNF systems. This indicates that CNF offers a more resilient and environmentally sustainable farming model.

This analysis offers compelling evidence that **labour productivity in natural farming hinges not only on individual contributions but critically on coordinated household labour strategies**. While such coordination drives gains in family labour productivity, its spillover benefits to hired labour and yields appear to be context-dependent. Gender roles, labour thresholds, and supporting inputs like biological practices and capital form the foundation of productivity in CNF systems. Future policy and research should continue to test, refine, and support these coordinated, resource-sensitive strategies for inclusive and sustainable agricultural growth.

5.6. Policy Implication

Overall, the study highlights the essential role of family labour coordination in improving farm productivity, especially in CNF systems. Gender-balanced labour practices, with both male and female members working together, significantly boost productivity. Additionally, the research underscores the need for innovations in technology and mechanisation to reduce the physical burden on women while enhancing overall farm efficiency. CNF systems are more sustainable and efficient, as they leverage biological inputs and capital, creating a balanced and resilient agricultural model. The findings also stress the importance of optimising hired labour through the strategic integration of family labour and capital, as seen in CNF systems. Ultimately, these takeaways suggest that future agricultural policies should mechanisation substitute coordinated family labour, improve mechanisation, and promote sustainable farming practices to enhance overall productivity.

The findings from this study emphasise the significant role of coordinated family labour in improving agricultural productivity. Notably, the active involvement of both male and female labour has been shown to enhance overall farm outcomes, including labour productivity and crop yields, in both natural farming (CNF) and chemical farming (non-CNF) settings. This suggests that policymakers should design agricultural policies that actively encourage gender-balanced farm labour use approaches.

i. Gender-Sensitive Agricultural Policies

Policymakers should consider gender-sensitive strategies that promote collaborative decision-making and task-sharing between male and female family members. Gender equality in agricultural labour is essential for achieving sustainable productivity improvements. Such policies could include support for training programs and awareness campaigns genders, highlighting the importance of gender collaboration in agricultural production. By equipping both men and women with the knowledge and skills needed for effective joint labour, policymakers can help optimise the overall family labour contribution to farming activities.

ii. Reducing Women's Labour Burden

Women play a critical role in agricultural production, yet their workload often remains disproportionately high, especially in resource-constrained farming settings. There is a clear need for policies that focus on reducing the burden on women while allowing them to remain active participants in farm activities. The introduction of labour-saving technologies and machinery, particularly those designed to assist with biological input preparation and soil conservation tasks, can play a pivotal role. Providing easier access to such tools will enhance productivity and allow women to participate more equitably in decision-making and higher-value farm activities. This would ensure their continued contribution to agricultural productivity without the undue physical and mental strain that typically accompanies their work.

iii. Leveraging Women's Collectives

Women's collectives have long been an effective platform for promoting empowerment, collective action, and community-driven agricultural development. These collectives should be further utilised to create a formal space for both male and female farmers to discuss natural farming practices and coordinated family labour use. Specifically, these platforms can facilitate dialogue on how best to integrate female farmers into decision-making processes, ensuring their contributions to farm management are recognised and valued.

By integrating gender-sensitive training and policy discussions within these collectives, it becomes possible to address both the practical and social challenges women face in agricultural production. This will empower women farmers and contribute to the overall success of the farming operation by ensuring that the potential of coordinated family labour is fully realised.

iv. Encouraging Male Involvement in Household Labour

Equally important is the active engagement of male family members in household and agricultural tasks. Policies promoting shared responsibility in farm work between male and female members of a household can lead to more balanced and productive labour use. These policies could incentivise male farmers to participate in training or workshops on natural farming techniques and collaborative decision-making. Further, social campaigns could work to challenge traditional gender norms, emphasising the importance of male participation in tasks that are critical for farm productivity, including those that were traditionally deemed as women’s work.

5.7. Future Research and Policy Development

Given this study's promising findings, future research should continue to explore how different forms of labour coordination and gender roles affect agricultural productivity across various regions and farming systems. Policymakers should continuously revisit their strategies and ensure that policies are dynamic, evidence-based, and adaptable to local agrarian contexts. A focus on integrating natural farming methods with gender-sensitive labour practices will help achieve not only higher productivity but also greater sustainability in the agricultural sector.

In conclusion, this study's results provide a foundation for future policy development aimed at enhancing agricultural productivity through coordinated family labour. Policies can foster a more inclusive and productive agricultural environment by addressing gender disparities in agricultural work, reducing women's burdens, and promoting joint decision-making.

Chapter 6

Impact of CNF on inputs use and investment

6.1. Introduction

In chapter 2, the impact of CNF on farming conditions, viz., cost of cultivation, yields and surpluses are covered. That chapter reconfirmed the superiority of CNF vis-à-vis non-CNF in terms of economic benefits. These apart, CNF has far more potential benefits in the form of soil/ natural resources conservation and their optimum utilization, optimum utilization of human resource, better human health, freedom and well-being of farmers. All these issues are discussed in detail in the previous Kharif Report 2023-24. Some of these issues are discussed briefly in this chapter. Before that a word of caution is warranted. It may be noted that one of the major objectives of the present study is to assess the impact of CNF on farming conditions of major crops in the state. Therefore, the study adopted the crops'-focused sample selection. The sample frame is prepared with the list of farmers, who are cultivating the sample crops in the selected GPs. ***CNF farmers who have gone beyond typical single crop cultivation and adopted the recommended cropping pattern such as model, multiple and mixed crops were excluded in the sample frame and therefore in sample selection***. Further, to get a minimum number of sample observations for each of sample crops, a stratified sample selection process was adopted. Because of these reasons, the estimated benefits from CNF with respect to input use, conservation of natural resources, crops' resilience to the vagaries of the monsoon, household income, human health, freedom from farming related stress, land utilization, own labour use, are, somewhat, under estimates.

In this chapter, the impact of CNF on the use of land, purchased inputs, such as agrochemicals, irrigation, farm investment and credit have been analyzed. The analysis is based on both quantitative and qualitative data collected from the farmers.

6.2. Impact of CNF on land utilization and quality improvement

As the APCNF is focusing on the holistic transformation of agriculture, its profound impact can be seen on the quality of land and its utilization. In the previous Kharif report these issues area covered extensively. The indicators covered are PMDS, season-wise utilization of landholdings, cultivation of mixed crops, cropping intensity and crop diversity. The findings include:

- By actively promoting PMDS, the project is increasing the cropping intensity.
- More than one indicator, such as percentage of operated area (number of plots) utilized in pre-monsoon season and average number of days of crop cover over operated area of CNF and non-CNF farmers, established the positive impact of CNF on cropping intensity.
- The positive impact of CNF on crop diversification has been established statistically.

In this section, the extent of land allocation to CNF, by CNF farmers, across the agroclimatic zones and framers' categories, is discussed. It demonstrates not only the potential benefits of CNF, but also indicate the extent of land, that is being revitalized. As discussed in previous reports, that land allocation to CNF would increase through (1) increase in the number of CNF farmers and (2) increase in area allocated to CNF by the existing farmers. As the data provided RySS, the number of farmers registered with RySS has been increasing continuously, crossing more than 10 lakhs as per the latest available information. It is noted in all previous surveys that farmers are continuously increasing the area allocation to CNF. The results of the present survey also indicate that the CNF farmers have increased area under CNF from 0.32 hectare in 2020-21 to 0.50. It may be worth mention here that, normally, the operated area may fluctuate from year to year owing to weather and other factors. But the farmers are increasing the area allocation to CNF continuously, not only in absolute terms, but also in relative terms. In the present context also, the CNF farmers have increased the area allocation to CNF from 45.2 percent of their operated area in 2020-21 to 53.9 percent in 2023-24 (Table 6.1). Similar increase can be seen across all agroclimatic zones and farmers' categories. The increase in area allocation to CNF indicates the potential benefits of CNF and growing farmers' interest and confidence in CNF. It also indicates the extent of land being regenerated.

Table 6.1: Area allocated to CNF, by CNF farmers during the last four Rabi seasons (ha)

Indicator	2020-21	2021-22	2022-23	2023-24
Area allocated to CNF in ha.	0.32	0.38	0.50	0.50
Area allocated as % of operated area	45.2	40.2	51.2	53.9

6.3. Use of fertilizers and pesticides

The foremost intervention of APCNF is the replacement of agrochemicals with bio-stimulants.

As per information provided by RySS, over 10 lakh farmers are registered with RySS and are using at least a couple practice/ input of CNF. Out of these, about 3.5 lakh farmers in the state are using the complete set of protocols and completely stopped the use of agrochemicals, at least in one plot of their operated holding. These are known as seed to seed (S2S) farmers. It may be recalled that this study selected sample CNF farmers from the list of S2S farmers. We have been collecting the data about crop wise use of agrochemicals by non-CNF farmers

This year an attempt was made to study the impact of CNF on the use of agrochemicals in other crops by CNF and non-CNF farmers. Detailed data was collected about the use of agrochemicals by CNF farmers in their non-CNF fields/ plots and mixed plots, in which both bio-stimulants and agrochemicals are used together. It was planned to collect the data for many crops. May be due to our crop wise sample selection strategy, we got very few observations of other crops, especially, for non-CNF farmers.[21] Because of this reason, we could analyze the data of five major crops, viz., Paddy, Groundnut, Cotton, Maize and Red gram, in Kharif report. But we could not get a minimum required number of observations for any crop to analyze agrochemical use by the CNF farmers in their non-CNF plots. Hence, the analysis in this section is limited to agrochemicals use in seven major crops, by non-CNF farmers in their non-CNF plots. These are considered as the avoided agrochemicals by CNF or S2S farmers.

On an average the CNF farmers avoided 5.07 quintals of fertilizers per hectare under S2S[22]. These include 1.12 quintals of Urea and 1.03 quintals of Complexes of nitrogen (N), phosphorus (P), and potassium (K) (NPK)[23]; 0.81 quintals of Di-ammonium Phosphate (DAP) and 2.11 quintals of other fertilizers (Table 6.2). In three major crops, the avoided fertilizers are over 6 quintals per hectare, ranges from 6.06 quintal per hectare in Groundnut to 6.99 quintal per hectare in Maize. In three pulses crops, the avoided fertilizers vary from 2.53 quintal per hectare in Green gram to 3.67 quintal in Black gram. In Ragi it is just below 2 quintal per hectare (Table 6.2).

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[21] It is well known fact that under non-CNF, the cropping diversity is reducing over the period. The present data lends yet another set of evidence to that trend.
[22] These are applied by non-CNF farmers in their fields; which are considered as quantities avoided by CNF farmers in their S2S fields
[23] In each type of complex, the three ingredients N, P and K are mixed in different proportions, like 15-15-15; 20-20-0; 12-11-18; etc.

Table 6.2: Crop-wise Avoided Chemical Fertilizers* by CNF Farmers During Rabi 2023-2024 (quintal/ hectare)

Crop\ Fertilizer	Urea	DAP	NPK	Others	Total
Paddy	1.70	1.04	1.62	2.54	6.89
Groundnut	1.13	1.49	0.90	2.53	6.06
Bengal gram	0.51	0.53	0.53	2.10	3.67
Maize	2.02	1.66	1.25	2.06	6.99
Black gram	0.48	0.23	0.53	1.68	2.92
Green gram	0.53	0.53	0.82	0.65	2.53
Ragi	1.02	0.97	.	0.00	1.99
Average$	***1.12***	***0.81***	***1.03***	***2.11***	***5.07***

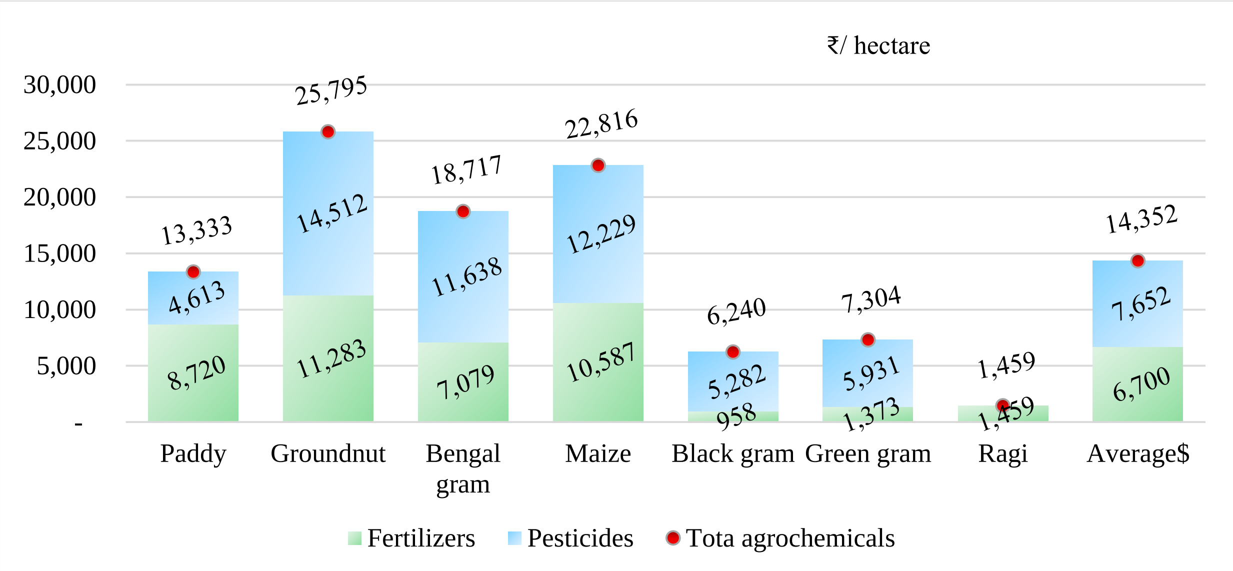
** These are applied by non-CNF farmers in their fields; which are considered as quantities avoided by CNF farmers in their S2S fields*

$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP

Source: IDSAP, Field Survey 2023-24

On an average the CNF farmers avoided the expenditure of ₹14,352 per hectare on agrochemicals in their CNF fields. This includes ₹6,700 on fertilizers and ₹7,652 on pesticides, weedicides and others. The avoided expenditure varies from ₹1,459 per hectare in Ragi to ₹25,795 per hectare in Groundnut and ₹22,816 in Maize (Figure 6.1). The avoided expenditure on agrochemicals is on lower side compared to that of previous Kharif results, due to the presence of low input intensive crops like three pulses crops and Ragi in the present sample crops.

Figure 6.1: Crop-wise avoided expenditure on agrochemicals* by CNF farmers during Kharif 2023-24



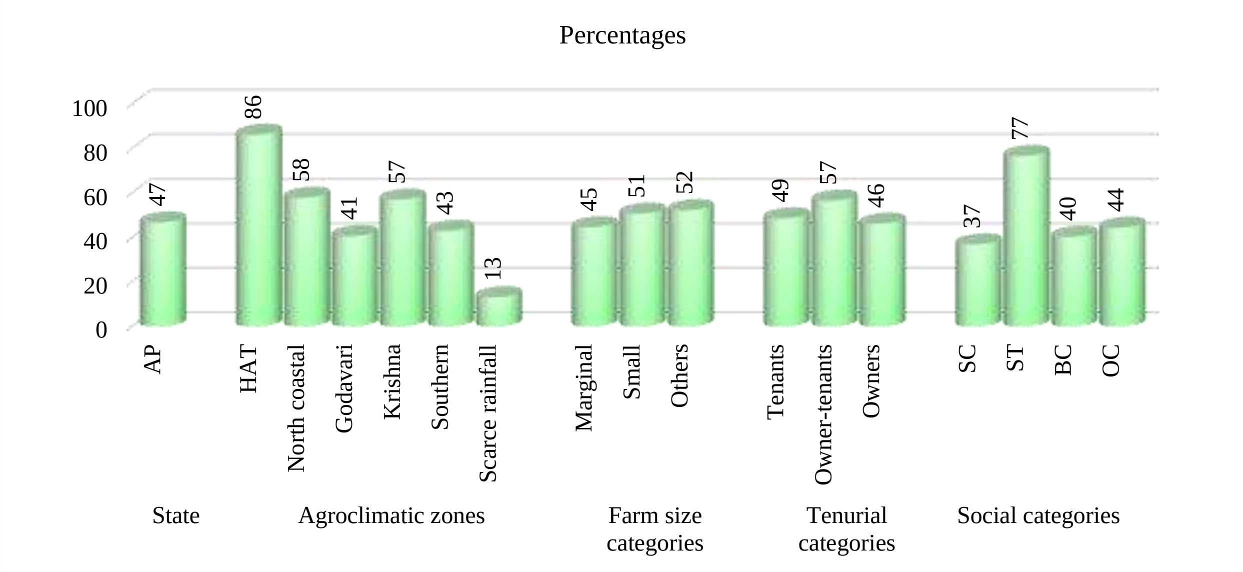
** These are applied by non-CNF farmers in their fields; which are considered as quantities*

avoided by CNF farmers in their S2S fields
[$] Weighted average of above six crops. The weights are the average area under these crops during previous five Kharif seasons ending 2022-23 in AP
Source: IDSAP, Field Survey 2023-24

6.4. Impact of CNF on water use for irrigation

Various CNF practices are expected to soften the soil and increase the carbon content in the soil. These changes in turn would increase the water/ rainfall percolation into the soils and increase the water/ moisture holding capacity of the soils. Farmers were asked about their experiences with respect to changes in water consumption in crop cultivation after the introduction of CNF, including PMDS. About 47 percent of CNF farmers have reported that water requirement for crop cultivation under CNF has reduced. But there are wide fluctuations in these percentages across the agroclimatic zones ranging from 13 percent in the Scarce rainfall zone to 86 percent in the HAT zone. A broad trend one can be inferred from the data is that a higher percentage farmer in high rainfall zone observed a positive impact on water conservation, due to CNF. Only exception is the Godavari zone, which has extensive canal irrigation, in which it is a bit difficult to observe the changes in the water utilization in the crop cultivation. However, these variations are quite low among different farm-size categories and also among different tenurial categories, in their perceptions about water requirement for crop cultivation under CNF (Figure 6.2). In case of social categories also, the variations are relatively less, barring the ST farmers. As mentioned above, the ST farmers are mostly confined to the HAT zone. The performance of HAT zone on any indicator, reflects in the performance of the ST farmers, as well.

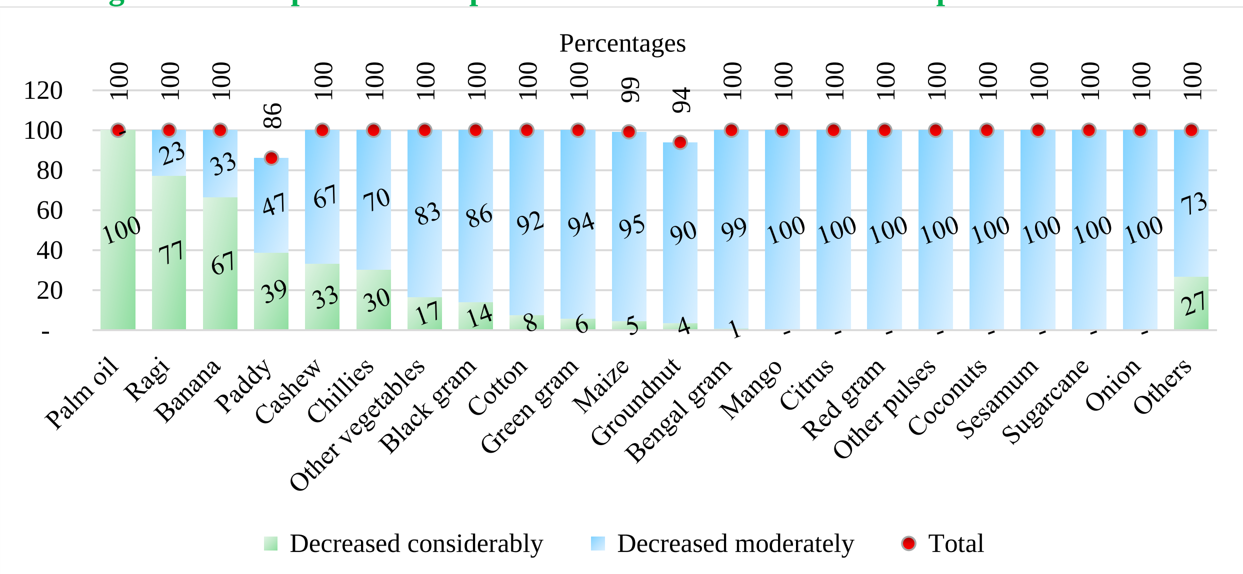
Figure 6.2: Agroclimatic zones and farmers' categories-wise percentage of CNF farmers perceived a reduction in water requirement in crop cultivation due to CNF during Rabi 2023-24



Source: IDSAP Survey 2023-24

The CNF farmers, who experienced a reduction in the water requirement in the crop cultivation, have perceived such reduction across many crops. A considerable reduction in water requirement is perceived in Palm oil cultivation by 100 percent of farmers, Ragi (77 percent) Banana (67 percent), Paddy (39 percent), Cashew (33 percent), Chilies (30 percent) and so on. On the other hand, 100 percent of farmers cultivating Mango, Citrus, Red gram, Other pulses, Coconut, Sesamum, Sugarcane and Onion reported a moderate reduction in water requirement (Figure 6.3).

Figure 6.3: Crop wise the impact of CNF on water needs in crop cultivation



6.5. Impact of CNF on human labour utilization

Human labour plays a critical role in CNF operations and expansion. CNF needs a higher quantity of human labour, especially, the own labour to perform a number of tiny/ small tasks, such as supervision, diagnosis of problems, need-based interventions, preparation of CNF inputs/ stimulants, exploration of new market channels, etc., which are spread across several days/ months. On the other hand, the agriculture in the state and country, in general, is not in a position to attract and retain the labour. Further, because of seasonal and crop life-cycle factors, there are peaks and troughs in the demand for labour. In this context, the study has been assessing the impact of CNF on labour utilization. In all the previous reports, the labour utilization pattern has been examined between CNF and non-CNF with regard to each major crop in terms of labour days per hectare. The human labour has been measured in terms of family (own), hired and total labour (family + hired labour). Labour utilization has been also analyzed in terms of male and female labour utilization and operation wise. It was mentioned in the previous Kharif report that as the study is focused on a comparative analysis of few major crops and ignored the model and horticulture crops in the sample selection, we are able to bring out only the partial impact of CNF on labour use.[24] In the previous studies, the following broad trends were observed, with respect to labour utilization:

a. CNF is requiring a greater number of labour days compared to that of non-CNF, in almost all crops and also on an average. At the same time, CNF is enabling households to utilize their labour, and also other agriculture assets, optimally during the off-season through PMDS and during trough periods through mixed and model crops.
b. CNF is utilizing more family labour. But there is no clear trend about gender wise changes in the labour use in CNF. As some of the agriculture operations are performed by both male and female members, their availability in a family determine gender-wise composition of labour use in some cases.

In this background, the results of present study are analyzed in this section. Detailed analytics are also given in the previous chapter. To get a summary understanding about the impact of CNF on labour use in crop cultivation, the weighted averages of all seven crops are worked

[24] Total impact of CNF on labour use can be obtained through two ways; (1) changes in technology and input use of a crop and (2) changes in the cropping pattern. Given the crop specific sample selection strategy adopted, this study provides the impact of mostly the first one.

out. The area under each crop, at the state level, are used as weights. Crop-wise labour used during the study period are presented in Table 6.3 and Figure 6.4. The Table also contains the difference in labour use in each crop and average of all crops. On an average 17 days or 23.8 percent of additional labour days are used per hectare in CNF crops. The total labour days per hectare are higher for CNF over non-CNF in four out of seven crops, included in this report, viz., Paddy, Groundnut, Bengal gram and Black gram, in the range of 11 days per hectare in Groundnut and 12 days in Bengal gram to 25 days in Paddy and 30 days in Black gram.[25] On the other hand, the labour use is marginally less under CNF in Maize (7 days per hectare), Green gram (2 days per hectare) and Ragi (2 days per hectare).

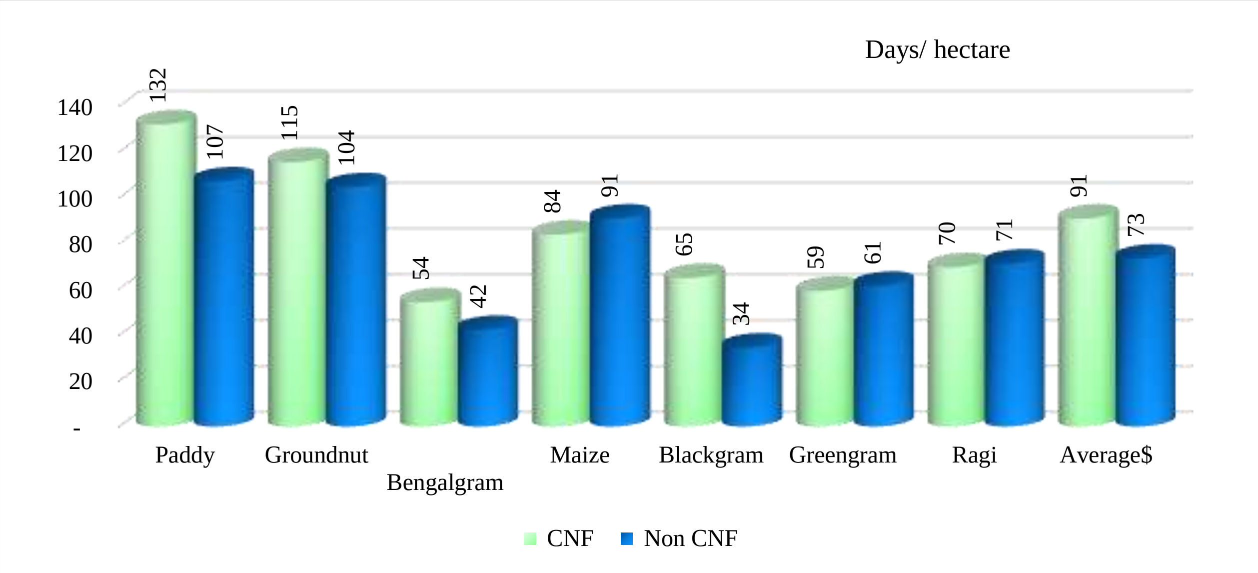
Table 6.3: Crop-wise and average[$] labour used under CNF and non-CNF and their difference during Rabi 2022-23

Crop	Days/ Hectare		Difference between CNF & non-CNF	
	CNF	Non-CNF	Days/ ha.	Percentage
Paddy	132	107	25	23.2
Groundnut	115	104	11	10.5
Bengal gram	54	42	12	28.7
Maize	84	91	-7	-7.8
Black gram	65	34	30	88.1
Green gram	59	61	-2	-3.6
Ragi	70	71	-2	-2.3
Average[$]	***91***	***73***	***17***	***23.8***

[$] Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP
Source: IDSAP: Field Survey, 2022-23

[25] The Black gram data not only in this chapter, but also in chapter 2 looks an outlier.

Figure 6.4: Crop wise and average$ labour used under CNF and non-CNF during Rabi 2022-23



$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP
Source: IDSAP: Field Survey, 2022-23

6.5.1. Utilization of male, female, own and hired labour

On an average 91 days labour is used under CNF vis-à-vis 73 days under non-CNF during the study period. Compared to previous Kharif report, the average number of labour days used are on lower side, under both CNF and non-CNF. This is because of crops covered in this report. Out of seven crops, the labour requirement is usually less in four crops, viz., Bengal gram, Black gram, Green gram and Ragi. The disaggregate data, in terms of male and female composition and own and hired composition and their four combinations are shown in Table 6.4, Figures 6.5, 6,6 and 6.7. Out of 91 days of labour used under CNF, 41 days are male labour and 49 are female labour days. The total labour days used in CNF include 53 own labour days and 38 hired labour days (Table 6.4). On an average, 17 additional days are used under CNF compared to non-CNF. These included 12 days of own labour and 6 days of hired labour.[26] It implies that CNF not only needs a higher dose of labour for crop cultivation, but most of that labour has to come from own labour. This could be a potential constraint in the expansion of CNF in the state. As mentioned in previous reports that preparation of biological stimulants such Jeevamruthams and Kashayams, which involve a number of small tasks such as collection of raw materials, cleaning, grading, mixing, drying, soaking, fermenting, boiling, etc., spread over many days. Casual or daily labour cannot be hired for those tasks. In addition,

[26] The two figures do not add up to total of 17 days, due to rounding off.

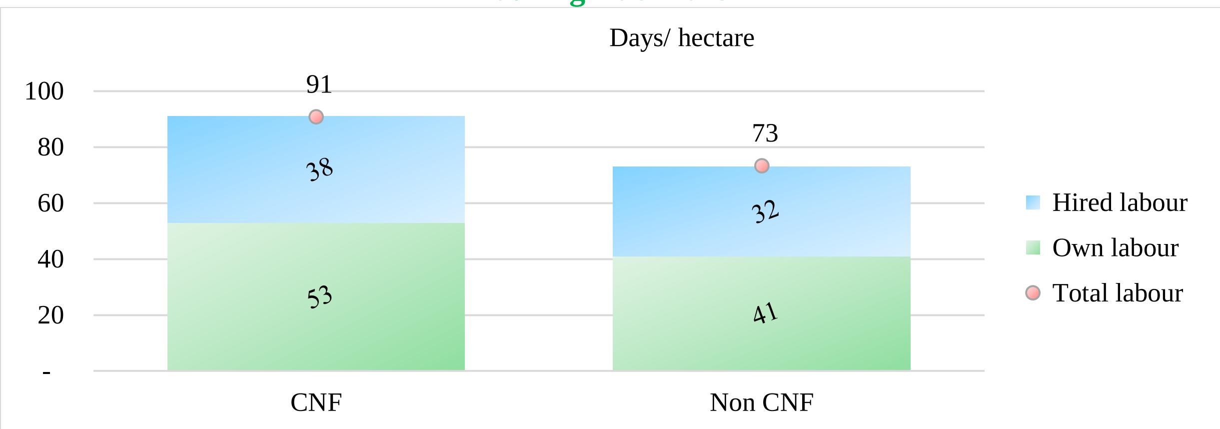
certain CNF operations also need few hours of labour frequently, if not daily. Such operations cannot be outsourced or hired labour cannot be employed for such tasks. Furthermore, CNF is promoting and facilitating higher cropping intensity or 365 days crop cover. In such condition many agricultural operations gets scattered over a longer span of time. For example, if a farmer takes PMDS, he/ she will complete the land preparation in March instead of in June or July. In such scenarios, the CNF farmers can optimize their own labour use and also the use of their own agriculture machinery and implements, more productively.

Table 6.4: Average$ own and hired labour days used under CNF and non-CNF during Rabi 2023-24

Crop	Days/ Hectare		Difference between CNF & non-CNF	
	CNF	Non-CNF	Days/ ha.	Percentage
Total labour	91	73	17	23.8
Total male labour	41	33	8	24.2
Total Female	49	40	9	22.5
Total own labour	53	41	12	29.3
Total hired labour	38	32	6	17.7
Own male	33	23	10	41.8
Hired male	8	10	-2	-17.7
Own female	19	18	1	5.6
Hired female	30	23	7	33.1

$ Weighted average of above seven crops. The weights are the average area under these crops during previous five Rabi seasons ending 2022-23 in AP

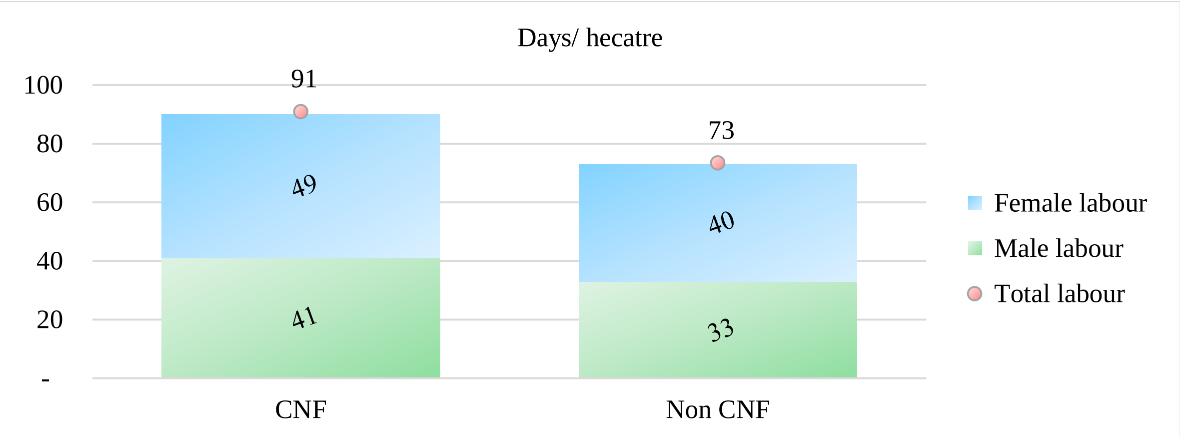
Figure 6.5: Average* own and hired labour days used under CNF and non-CNF during Rabi 2023-24



** Weighted average of seven crops covered in this report. The area under each crop, at the state level, are used as weights.*
Source: IDSAP: Field Survey, 2023-24

It is conclusive that CNF needs not only more human labour, but also uses more family labour. However, it is not so obvious about the use of male and female labour. As the CNF is evolving, its need for male and female labour requirement is also evolving. Further, at the family level it is availability of labour that determine the labour use. In the present case also, almost equal number of additional male and female labour days are used in CNF. Out of 17 additional days used per hectare in CNF, 8 and 9 days of male and female labour respectively. In relative terms 24.2 percent of additional male labour and 22.5 percent of female additional labour are used (Figure 6.6 and Table 6.4).

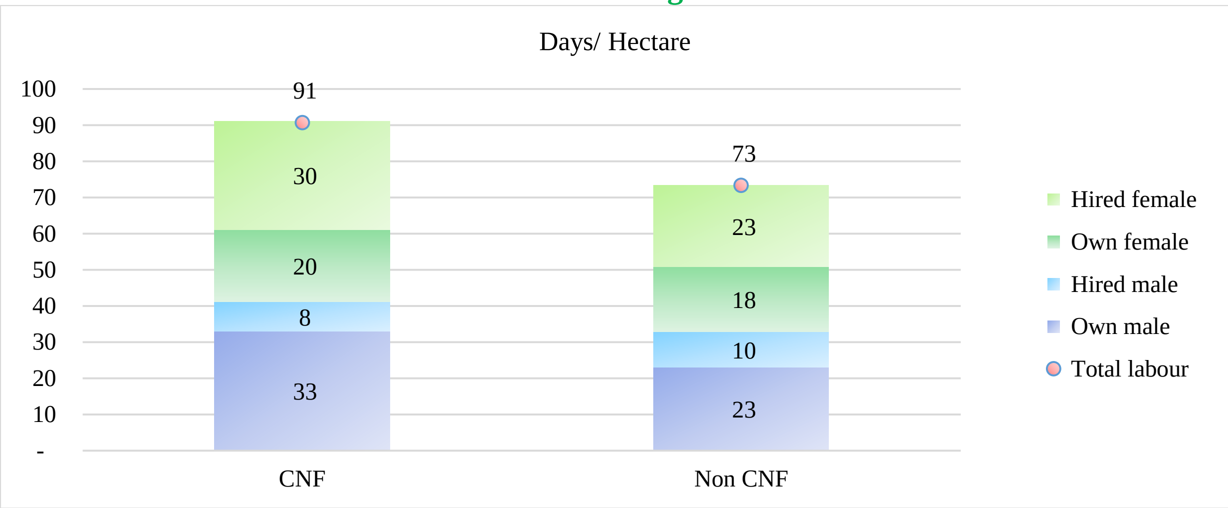
Figure 6.6: Average* male and female days used under CNF and non-CNF during Rabi 2023-24



** Weighted average of seven crops covered in this report. The area under each crop, at the state level, are used as weights.*
Source: IDSAP: Field Survey, 2023-24

Out of four sub-categories of labour used, viz., (1) own-male, (2) own-female, (3) hired-male, and (4) hired-female, a greater number of labour days are used in three sub-categories, only exception is the hired-male labour (Figure 6.7 and Table 6.4). Crop-wise details of labour use are given in the appendix Table 6.1 at the end of this chapter.

Figure 6.7: Average* own and hired labour and male and female days used under CNF and non-CNF during Rabi 2023-24



** Weighted average of seven crops covered in this report. The area under each crop, at the state level, are used as weights.*
Source: IDSAP: Field Survey, 2023-24

6.5.2. Changes in labour use in different agricultural operations

The study has collected labour use details on different agricultural operations under CNF and non-CNF. The operations covered are land preparation, nursery raising, crop sowing/ transplantation, weeding and inter-cultivation, irrigation, crop harvesting, threshing and supervision, including other miscellaneous expenditure. The average labour used[27] on each of these operations under CNF and non-CNF is presented in Table 6.5 and Figure 6.8. A greater number of labour days are utilized in all, but one operation, under CNF over non-CNF. In absolute terms, the difference between CNF and non-CNF crops varies from minimum of one day in each of land preparation and sowing/ transplantation to maximum of five days in irrigation and four days each in Threshing and Supervision. On average (weighted average of seven crops), 17 days (23.8 percent) of additional labour is used under CNF vis-à-vis non-CNF. The CNF farmers saved 4 labour days in weeding and inter-cultivation. This finding is in line with the assertion of RySS- that the weed growth would be suppressed through 365 crop on the fields and also through mulching. On the other hand, the CNF farmers spend 5 additional labour days on irrigation. As CNF needs less water, the water flow needs to be controlled. It also involves application of Ghanajeevamrutham and Dravajeevamrutham. Further, each CNF farmer spends four additional labour days on supervision. As CNF is

[27] Weighted average of seven crops covered in this report. The average area under each crop during last five Rabi seasons, ending with 2022-23, at the state level, are used as weights

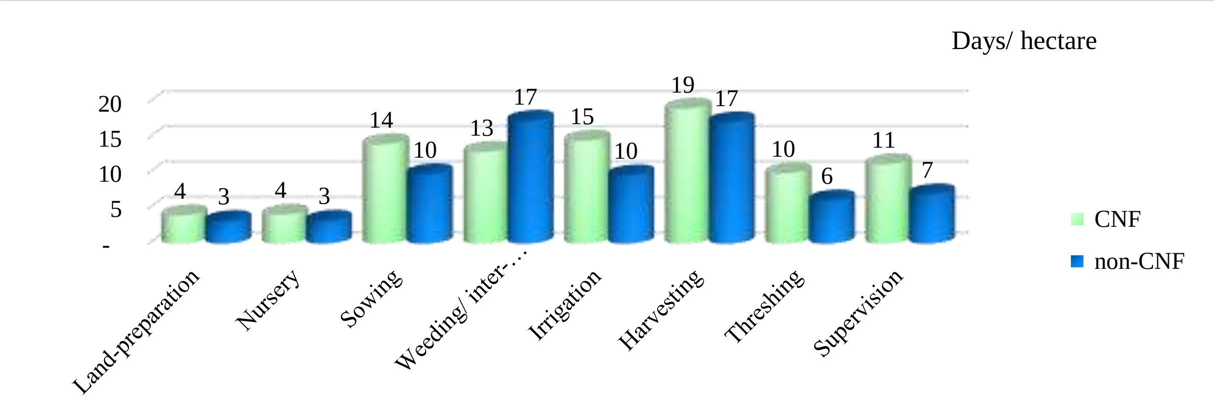
evolving, it is being practiced as action research by the participants. Each farmer devotes relatively more time on supervision. It may be noted that CNF is encouraging and facilitating cultivation of mixed crops or cultivation a few minor crops/ plants along with the main crop, and also cultivation traditional crops like Red rice, Black rice, etc. Such practices would result in an additional care and efforts in the crop harvesting and threshing.

Table 6.5: Average* labour use on different agricultural operations under CNF and non-CNF during Rabi 2022-23

Operation	Days/ Hectare		Difference between CNF & non-CNF	
	CNF	non-CNF	Days/ ha.	Percentage
Land-preparation	4	3	1	25.6
Nursery	4	3	1	27.0
Sowing	14	10	4	43.4
Weeding/ inter-cultivation	13	17	-4	-25.3
Irrigation	15	10	5	51.1
Harvesting	19	17	2	11.3
Threshing	10	6	4	63.2
Supervise	11	7	4	61.5
All activities	91	73	17	23.8

** Weighted average of seven crops covered in this report. The average area under each crop during last five Rabi seasons, ending with 2022-23, at the state level, are used as weights*

Figure 6.8: Average* labour use on different agricultural operations under CNF and non-CNF during Rabi 2022-23



* Weighted average of seven crops covered in this report. The average area under each crop during last five Rabi seasons, ending with 2022-23, at the state level, are used as weights

6.6. Impact of CNF on credit

A noteworthy reduction in the paid-out cost of cultivation in almost all crops is expected to reduce the working capital requirements for CNF, which in turn, is expected to result in a reduction in the CNF farmers' borrowing for agriculture and other uses. CNF farmers' perceptions and experience about the impact of CNF on funds requirement for cultivation and borrowing for agriculture are shown in Figure 6.9 and Table 6.6. Not surprisingly, nearly 93 percent of farmers reported a reduction in funds/ investment requirements for agriculture; and nearly 92 percent of CNF farmers perceived a reduction in borrowing for agriculture. Nealy 69 percent of famers reported a reduction in borrowings from informal sources and 38 percent stated a reduction in the interest rates in the informal credit markets in their locations/ villages. Interestingly, relatively a higher percentage (22 percent) of CNF farmers perceived a considerable reduction in the borrowings from the informal sources, due to CNF.

Figure 6.9: CNF farmers response about change in funds requirement and borrowing for agriculture related indicators, due to CNF in Rabi 2023-24

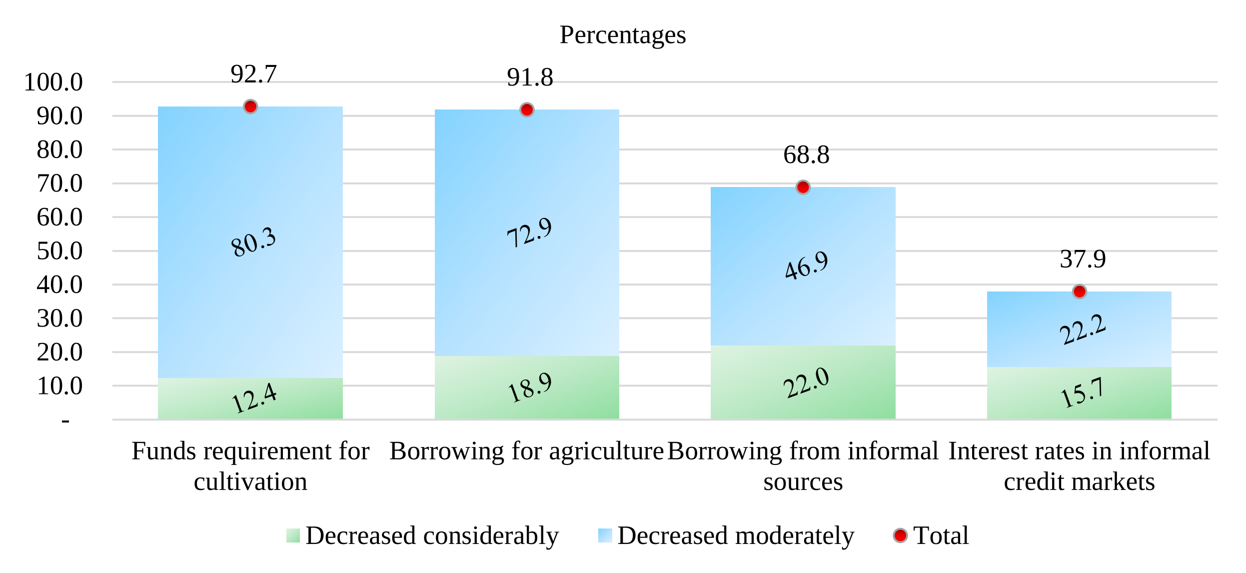


Table 6.6: CNF farmers response about change in funds requirement and borrowing for agriculture related indicators, due to CNF in Rabi 2023-24

Indicator	Decreased considerably	Decreased moderately	No change	Increased moderately	Increased considerably
Funds requirement for cultivation	12.4	80.3	3.7	3.4	0.3
Borrowing for agriculture	18.9	72.9	8.0	0.2	
Borrowing from informal sources	22.0	46.9	30.7	0.5	
Interest rates in informal credit markets	15.7	22.2	61.7	0.4	

Even the hard data collected from the farmers confirmed a considerable reduction in the borrowings for the cultivation.[28] In every aggregated parameter with respect to borrowing, such as percentage of sample farmers borrowed, average borrowed amount, loan outstanding

[28] This data was analyzed in detail in the previous Kharif Report 2023-24. The same is summarized in this section.

amount, etc., the CNF farmers fared better (Table 6.7). In addition to borrowing less amount, the CNF farmers are able to repay a part of their loans. As a result, their loan outstanding amount is less than their borrowed amount at the time of the survey. On the other hand, the non-CNF farmers' loan outstanding is greater than their borrowed amount. Compared to the CNF farmers, the non-CNF farmers have relatively more long-standing loans. The average length of loan outstanding is 1.45 years for non-CNF farmers vis-à-vis 1.26 years for CNF farmers.

Table 6.7: Borrowing by CNF and non-CNF farmers at the time of survey in the years 2023-24: Different parameters

Indicator	Unit	CNF	non-CNF
Number of sample farmers	Number	1,348	842
Number of loanees	Number	631	472
Percentage number of indebted sample farmers		47	56
Number of Loans	Number	639	487
Number of loans per loanee	Number	1.01	1.03
Total Borrowed amount	₹	4,95,97,350	4,06,86,431
Average borrowed amount per sample farmer	₹	36,793	48,321
Average borrowed amount per loanee	₹	78,601	86,200
Total loan outstanding	₹	4,57,30,035	4,23,71,888
Average loan outstanding amount per sample farmer	₹	33,924	50,323
Average loan outstanding amount per loanee	₹	72,472	89,771
Average length of outstanding amount	Years	1.26	1.45

Source: IDSAP, Field Survey 2023-24

Purpose-wise distribution of loanees and borrowed amount indicates that CNF farmers borrowed relatively less percentage of amount (79 percent) vis-à-vis 90 percent by non-CNF farmers for agriculture. It indicates the lower investment requirement for CNF. On the other hand, CNF farmers borrowed 14 percent of total loan amount for the consumption purpose, compared to 5 percent by non-CNF farmers. The possible reasons could be an improvement in food intake by CNF farmers, due to their elevated farm income. Another possible reason could be that the proportion of poor and vulnerable sections may be high in CNF households. In the present sample also, the share of the poor and vulnerable sections such as SC and ST farmers, marginal and small farmers and tenant farmers are high by two percentage points.

The more interesting inferences one can draw from the data, in Table 6.8, are that CNF farmers borrowed 2 percent of total loan amount for assets/ land purchase and 1 percent for business. The same are 1 percent and 0 percent respectively for non-CNF farmers. This shows that CNF is leading to more diversified income and employment opportunities to the participating farmers.

Table 6.8: Purpose-wise distribution of loanees and borrowed amount by CNF and non-CNF farmers in 2023-24

Purpose	Percentage of loanees		Percentage of Borrowed amount	
	CNF	non-CNF	CNF	non-CNF
Agriculture	72	86	79	90
Consumption	20	8	14	5
Assets/ land purchase	1	1	2	1
Health	2	2	1	1
Life cycle events	2	1	1	0
Business	1	-	1	-
Education	1	1	0	0
Others	1	2	1	3
All	100	100	100	100

Source: IDSAP, Field Survey 2023-24

6.7. Conclusion

Apart from economic benefits, CNF has far more potential benefits in the form of soil/ natural resources conservation and their optimum utilization, optimum utilization of human resource, better human health, freedom and well-being of farmers. As the study adopted the specific crops' focused sample selection strategy, we could estimate only partial impact on CNF on all these indicators in the previous Kharif report. In this chapter, we have provided further evidence about the benefits of CNF with respect to land utilization, use of agrochemicals, water requirement and farm credit. Even the partial impact of CNF appeared to be substantial and overwhelming majority of participants are perceiving these benefits.

Appendix Tables of chapter 6

Appendix Table 6.1: Crop-wise male, female, own and hired labour used under CNF and non-CNF during Rabi season 2023-24

Labour categories	Crop	Male Labour (Days/ hectare)		Female Labour (Days/ hectare)		Total Labour (Days/ hectare)		Difference between CNF & non-CNF in total labour days	
		CNF	non-CNF	CNF	non-CNF	CNF	non-CNF	Days/ ha.	Percentage
Own labour	Paddy	50	37	26	30	76	68	8	12
	Groundnut	36	35	28	27	64	62	2	3
	Bengal gram	13	9	13	9	27	18	9	51
	Maize	36	27	15	11	51	37	14	36
	Black gram	26	13	19	6	45	19	26	142
	Green gram	22	17	10	11	32	28	3	12
	Ragi	30	32	35	38	65	71	-6	-8
	Average	33	23	19	18	53	41	12	29
Hired labour	Paddy	18	21	37	19	56	39	17	42
	Groundnut	5	4	46	38	51	42	9	21
	Bengal gram	0	0	28	25	28	25	3	13
	Maize	4	12	29	42	33	54	-21	-38
	Black gram	3	3	17	13	20	16	4	25
	Green gram	3	3	24	30	27	33	-6	-17
	Ragi	0	0	4	-	4	-	4	-
	Average	8	10	30	23	38	32	6	18
Total labour	Paddy	69	58	63	49	132	107	25	23
	Groundnut	42	39	74	65	115	104	11	10
	Bengal gram	13	9	41	34	54	42	12	29
	Maize	40	39	44	52	84	91	-7	-8
	Black gram	29	16	36	18	65	34	30	88
	Green gram	25	21	34	41	59	61	-2	-4
	Ragi	30	33	39	38	70	71	-2	-2
	Average	41	33	49	40	91	73	17	24

Chapter 7

Issues, challenges and way forward

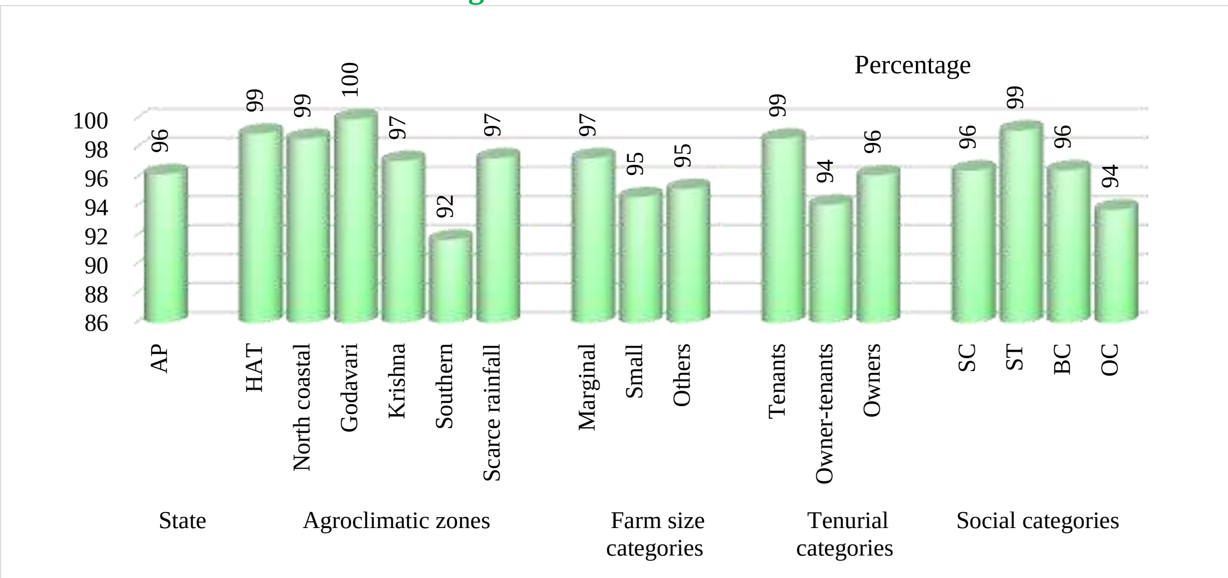
7.1. Introduction

CNF proved to be beneficial to the farmers. It is not only economically viable, but also sustainable economically, socially and environmentally. Previous chapters provided enough evidence about how the CNF is improving the farm profitability, reaching and benefitting resource poor regions and sections. However, CNF is facing certain issues and challenges. Some of the issues such as continuing agriculture and marketing of agriculture output are generic problems which are even more acute for non-CNF. In case of CNF, marketing of CNF output perse is not a big problem, but getting a premium/ higher prices is a challenge. Further, CNF farmers are facing some supply side bottlenecks, such as shortage of CNF/ stimulants/ inputs, extension services, labour, etc. These issues and challenges are discussed briefly in this chapter. Further, a few suggestions are made for the improvement of the program and its implementation.

7.2. Willing to continuing CNF

As mentioned above the issue of continuation in farming is a generic problem. Various official documents indicate that a sizable portion of farmers are not willing to continue in agriculture. At least they do not want their children to take up the farming. In this background, 96 percent of CNF farmers willingness to continue the CNF is remarkable phenomenon. This willingness continue with the CNF is spread almost evenly across all agroclimatic zones and each and every category of farmers. The variations across agroclimatic zones are in the range of 8 percentage points only; varying from 92 percent in Southern zone to 100 percent in Godavari zone. The variations across different farmers categories are in the range of 2 percentage points among the farm size categories, 5 percentage points in both tenurial and social categories (Figure 7.1).

Figure 7.1: Agroclimatic zone-wise and farmers categories-wise percentage of CNF farmers willing to continue the CNF in Rabi 2023-24



Source: IDSAP, Field Survey 2023-24

7.3. Commanding respect but not able to market it

Under CNF, the participating farmers are not only economically better off, but also socially respected. General public, including the consumers, officials, political leaders, and traders started looking at CNF farmers as saviours of nature, environment, human health, traditional seeds, crops and biodiversity. They are also viewed as the innovators, model farmers, social entrepreneurs, etc. All these are resulting into an admiration and respect to the CNF farmers. Over 80 percent of farmers reported an increased admiration form the CNF output consumers and users. Further, 86 percent of CNF farmers stated that they are getting respect from their relatives and friends. Out of these about one-third reported that they are getting a considerable increase in the respect they command from their relatives and friends. It was observed that many CNF farmers are supplying or sharing their output with their friends and relatives, on priority. Many CNF farmers reported that they are getting recognition and respect from the market administrators. They are getting priority in allocation of shops, space and entry of their vehicles into markets. As many as 76 percent of CNF farmers reported an increase in the respect, they get from market administration. But only 15 percent reported a considerable improvement in the respect they command. Many district project managers (DPMs) said that their colleagues from different departments in the District Administration, are sourcing their provisions such as foodgrains, vegetables and fruits from CNF farmers, through the DPM office. All these respect and interests are contributing to the development of new market channels. Many traders and consumers ae visiting the villages and houses of CNF farmers and purchasing CNF crop output. About 56 percent of CNF farmers perceived an increase in market channels for CNF output (Figure 7.2 and Table 7.1). However, only eight percent of farmers reported a considerable increase in the market channels for APCNF output. Further, only a handful of CNF farmers obtained higher prices for their CNF crop output.

Figure 7.2: Percentage of CNF farmers, who reported an increase in respect they get from different categories of people, due to CNF, in Rabi 2023-24

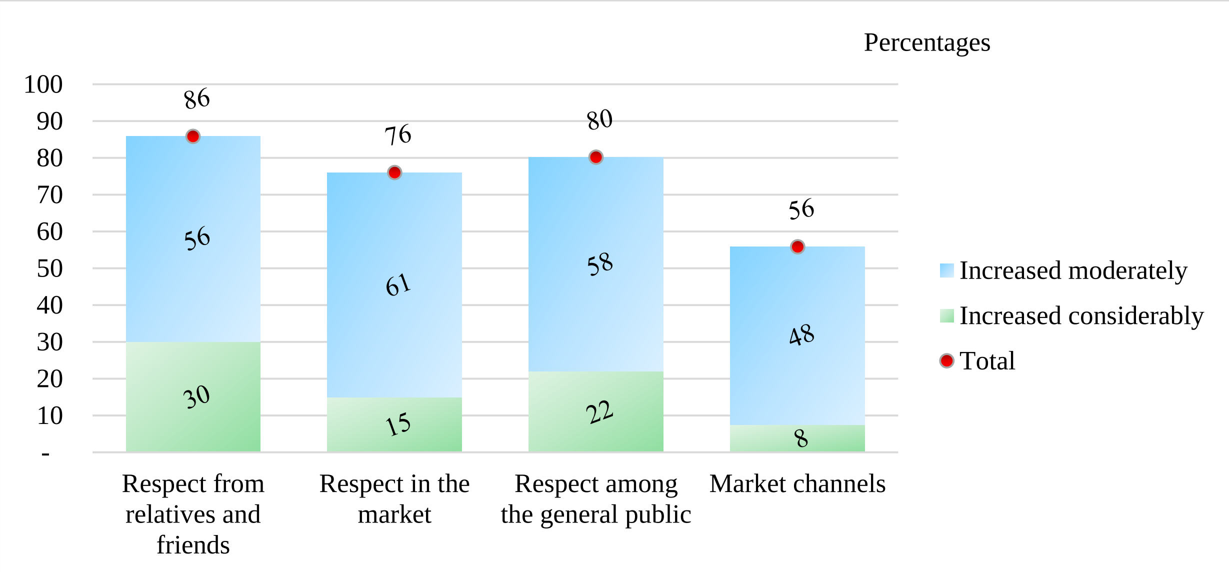


Table 7.1: CNF farmers responses about the respect they are getting and emergence of new market channels during Rabi 2023-24 (%)

Indicator	Increased considerably	Increased moderately	No change	Decreased moderately	Decreased considerably
Respect from relatives and friends	30.15	55.72	13.11	0.80	0.22
Respect in the market	14.94	61.08	22.89	0.95	0.15
Respect among the general public	22.05	58.15	17.61	1.97	0.22
Market channels	7.5	48.36	43.63	0.44	0.07

Source: IDSAP, Field Survey 2023-24

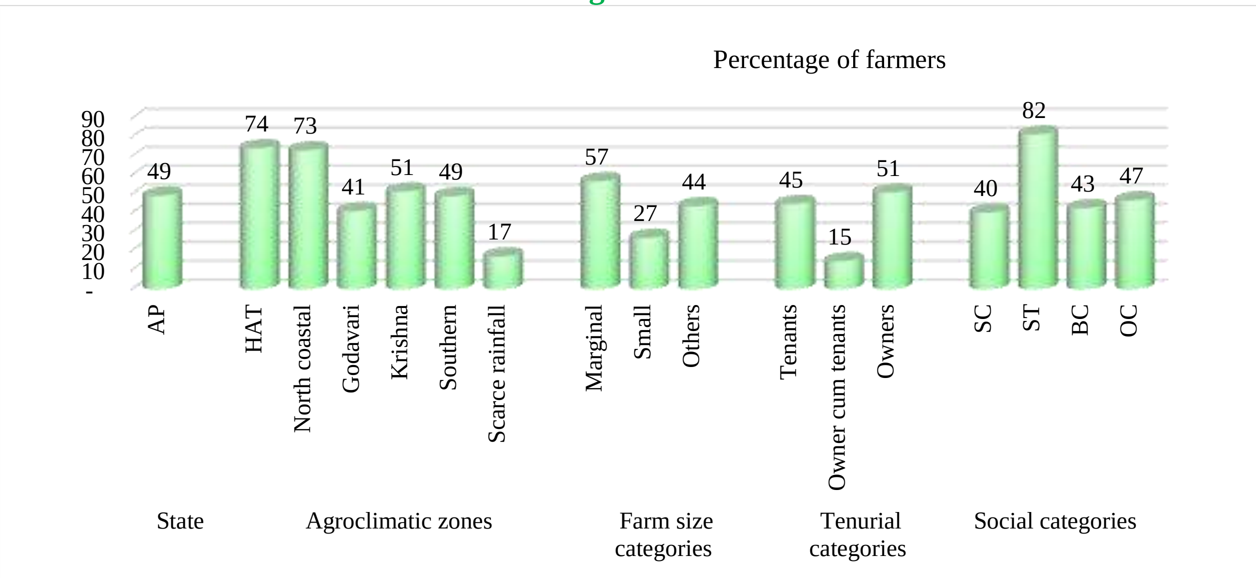
7.4. Challenges in adopting CNF

CNF proved to be economically profitable and sustainable. Further, the program is expanding at a fast pace in the state due to the efforts of RySS. But now a days, RySS is, apparently, focusing on deepening the program through development of models and action research; less focus on horizontal expansion by covering more farmers and area. However, voluntary replication by the farmers is tardy. Even converting the entire operated holding into CNF is also slow. The challenges in the spontaneous expansion of CNF are discussed briefly in this section.

7.4.1. CNF whole

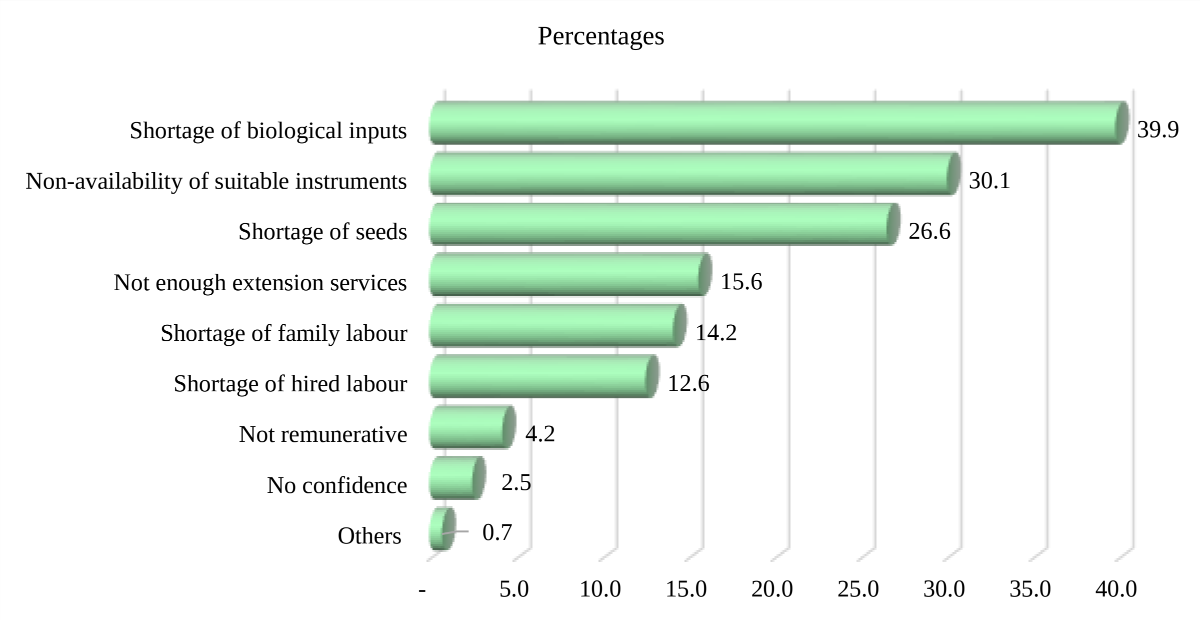
A farmer, who cultivates a crop with only CNF inputs and processes, without using any agrochemicals, at least in a part of his/ her operated holding, is known as S2S or CNF farmer. If a farmer adopts only CNF inputs and processes and stop completely the use of agrochemicals on his/ her entire operated area, he/ she would be referred as CNF-whole (CNF-W) farmer. During the study period about 50 percent of farmers allocated their entire operated area to CNF. There are wide variations across the agroclimatic zones ranging from 17 percent in the Scarce rainfall zone to 74 percent in the HAT zone. These variations are relatively moderate across different farmers categories (Figure 7.3). The data indicates that agroclimatic conditions are more influential factors in allocation of area to CNF. Perhaps the local project administration might have also some influence on the progress of the project.

Figure 7.3: Percentage of CNF farmers, who allocated their entire operated area to CNF during Rabi 2023-2024



The reasons cited, for not allocating their entire operated holdings to CNF, include shortage of CNF stimulants/ inputs (40 percent), nom-availability of suitable instruments for preparation of CNF stimulants (30 percent, shortage of seeds (26.6 percent), inadequate extension services (15.6 percent), shortage of family labour (14.2 percent), shortage of hired labour (12.6 percent), and so on (Figure7.4). These are specific factors preventing some of the existing farmers from increasing their operated area under CNF. Apart from these, there are some general problems affecting all farmers, while adopting the CNF. These issues are discussed below.

Figure 7.4: Reasons cited by CNF farmers, for not allocating the entire holding for CNF during Rabi 2023-2024

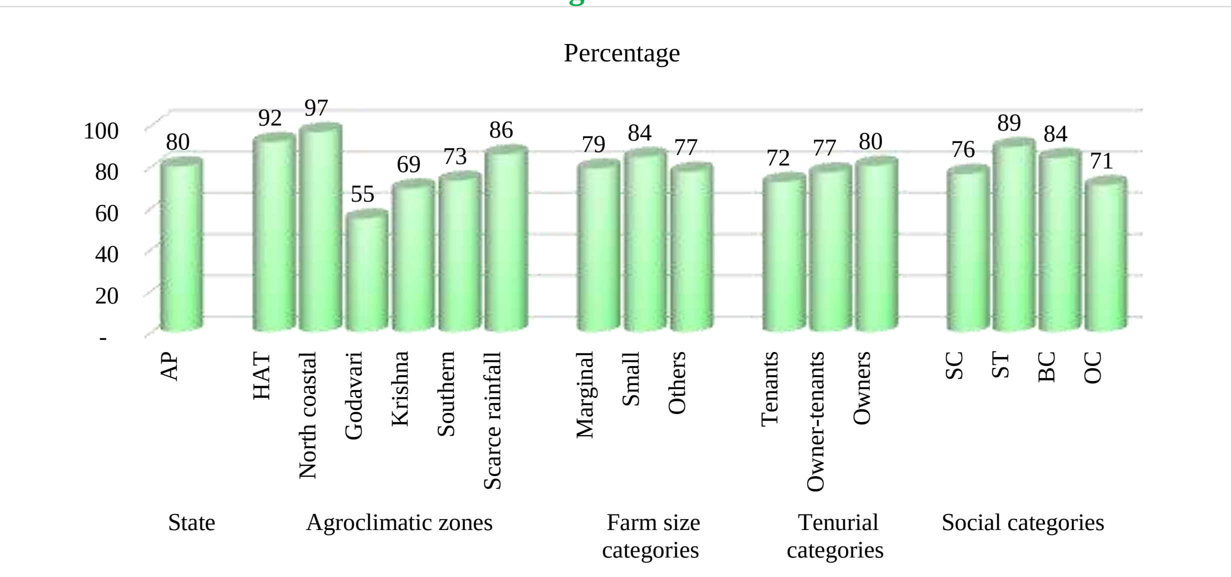


7.4.2. Challenges faced, while adopting CNF

At the state level, 80 percent of farmers reported one problem or the other while adopting CNF. Compared to earlier studies, a greater number of farmers reported one problem or the other. The possible reasons could be integration of PMDS in CNF, expansion of the program, which may be resulting in more shortage of various inputs, including labour, increased marketing challenges due to increase in the CNF output, and shortage of extension services due to expansion of the program and shortage of staff, etc.

Across the zones, highest percentage of farmers in HAT zone (92 percent) and North Coastal (97 percent) reported challenges, indicating severe adoption barriers in these regions. On the other hand, relatively a fewer percentage of farmers in Godavari zone (55 percent), Krishna zone (69 percent), and Southern zone (73 percent) reported one problem or the other; suggesting fewer constraints compared to other zones. In the farm size-wise categories, a higher percentage of small farmers (84 percent) and marginal farmers (79 percent) reported challenges, possibly due to resource limitations. Other farmers (77 percent) – face slightly fewer challenges, likely due to better access to inputs and resources. Across the tenurial categories, tenants (72 percent) and owner-tenants (77 percent) are facing relatively fewer challenges, may be due to their extensive and direct involvement in the farming. Owner farmers (80 percent) are facing slightly higher number of challenges. Social category-wise, ST (89 percent) and BC (84 percent) face the most difficulties, indicating socio-economic and also regional barriers in CNF adoption. SC (76 percent) and OC (71 percent) have relatively fewer challenges, possibly due to better resource access and regional factors (Figure 7.5). The variations with respect to challenges faced by the farmers, while adopting CNF, are quite large across the agroclimatic zones, compared to that of different farmers' categories. As mentioned above, apart from agroclimatic conditions, the performance of local project teams determine the number and nature of challenges faced by farmers in the adoption of CNF.

Figure 7.5: Percentage of CNF farmers reported any challenges in adoption of CNF during Rabi 2023-24

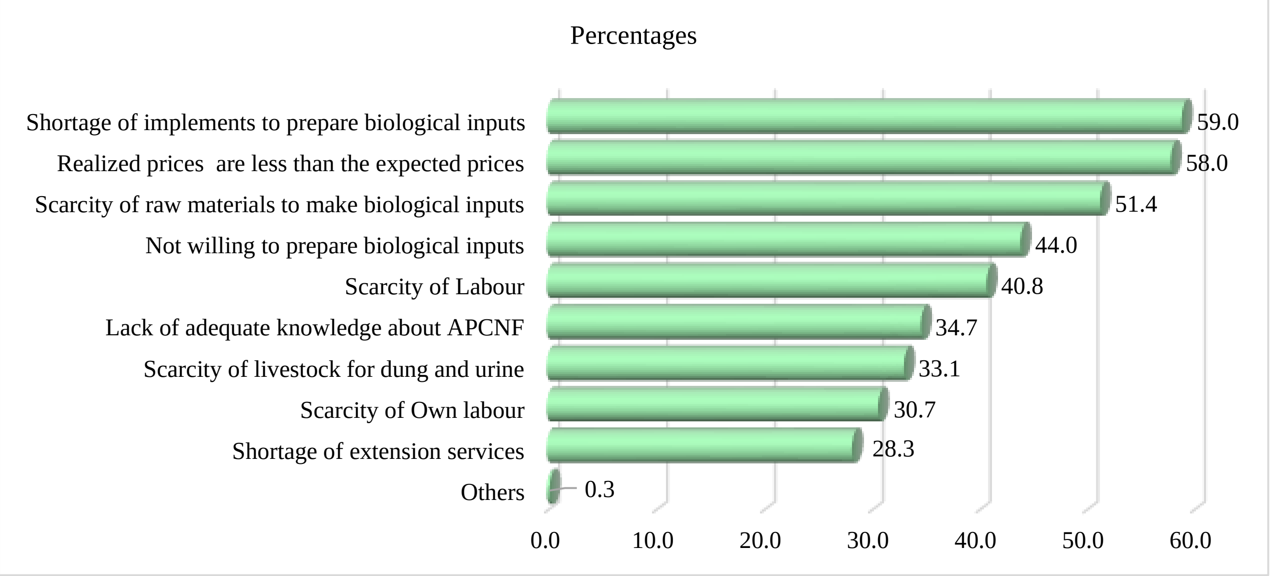


Source: IDSAP, Field Survey 2023-24

Percentage of farmers, who reported different challenges, while adopting CNF during the study period are shown in Figure 7.6. Needless to say, all these challenges are not mutually exclusive, some farmers might have cited more than one challenge. Among all, problems related to supply of CNF stimulants/ inputs are more in number. About 59 percent of farmers reported that non-availability or shortage of suitable equipment and implements, such as blenders, drums, mostly for the preparation of CNF inputs as a major constraint. Another 44 percent of farmers reported non-availability of workers, including family members, who are willing to the prepare CNF inputs. Further, 51.4 and 33.1 percent of farmers mentioned scarcity of raw material and livestock for dung and urine for the preparation of CNF inputs as constraints, respectively. Yet another constraint related to the CNF input supply is inadequate knowledge to prepare the CNF inputs. This is cited by 34.7 percent of farmers, which is somewhat related to extension services.

Apart from the input supply related challenges, marketing of CNF output at a little higher price is major challenge cited by 58 percent of farmers. Further, scarcity of hired labour and own labour as constraints, are cited by 40.9 percent and 30.7 percent of farmers respectively. It may be worth mentioning that labour shortage is not an exclusive issue in CNF. Non-CNF farmers also cite the same problem. Last, but not the least, 28.3 percent of farmers reported extension services as the limiting factor.

Figure 7.6: Percentage of farmers, who reported different challenges, while adopting CNF in Rabi 2023-24



Source: IDSAP, Field Survey 2023-24

7.4.3. Extension services

As mentioned in the previous report, RySS is the only source of extension service and knowledge and awareness generation. As per our field observations and media reports, RySS is not able to retain a large number of field personnel, and not able to provide the extension services at the desired scale. As mentioned above, about 34.7 percent of farmers reported about inadequate knowledge to prepare CNF inputs and 28.3 percent of farmers cited shortage of extension services.

7.4.4. Other challenges

Apart from the above, the detailed analysis of all the data and insights gained by the research team point at the following challenges.

1. Price incentive. The CNF farmers feel that their output is valuable and they put in a lot more effort, therefore deserve a higher price for their output. Out of a total 1,348 sample farmers, only a handful received higher price.
2. There is a need for designing and developing appropriate tools for different CNF operations, especially for preparation of the stimulants.
3. Though at the state level, the CNF farmers are better off vis-à-vis non-CNF farmers, it is not true in one zone or the other or one farmers' category or the other, at disaggregate level, in every year.[29]
4. Though the coverage of CNF is expanding at fast pace, to cover the entire cropped area and all farmers in the state, out of the box strategies may have to adopted.
5. Still the bulk of state government's support to agriculture is going to non-CNF or chemical-based farming. Many CNF farmers question this.

7.5. Way forward

1. There is a need for larger budgetary allocation to the CNF
2. Various government incentive schemes may be integrated with CNF. For example, PMDS seed kits may be distributed instead of the kits of green manure crops. Similarly, CNF output may be procured for the public distribution systems (PDS), Midday Meal, Anganwadi Centers, Anna Canteens, Residential hostels, etc.
3. The services of the Agriculture Departmental extension persons may be obtained in the CNF GPs.
4. A 5 to10 percent price incentive over and above the Government of India's minimum support price may be given to CNF farmers. It could be a game changer.
5. As of now, the project is the only source of extension services. The project is also utilizing the services of SHG institutions to some extent. The project may

[29] One of the reasons is that our sample size is adequate to provide robust estimates at the state level only. Disaggregate results should be used with caution.

also consider to involve other institutions like Panchayat Raj Institutions (PRIs), non-government organizations (NGOs), local cooperatives, corporate bodies, etc., for the expansion of the program at an accelerated pace.

6. Appropriate tools for different CNF operations, especially for preparation of the stimulants, may be designed, developed and distributed.
7. A CNF input/ stimulant supplying shops may be promoted in each GP.

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Madhurawada, Visakhapatnam 530041

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