# MINIMIZATION OF TRANSPORTATION COST FOR RICE DISTRIBUTION SYSTEM IN ORISSA.

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There are some systems prevailing in India for allocation, transportation and distribution of rice among various states as well as among various districts within a state causing higher and unequal costs of transportation. It is suggested that some modern and scientific system giving minimum cost of transportation may be adopted. Among of them, there are the following four systems, which may be adopted easily and widely:

(i) North west corner method (NWCM)
(ii) Minimum cell method (MCM)
(iii) Vogall approximation method (VAM)
(iv) Modified distribution method (MDM)

The system has been designed for rice distribution in Orissa state, which may be utilised for other areas and for other food grain for transportation and distribution.

## BASIC DATA FOR THE DESIGN AND FORMULATION OF THE PROBLEM

The data regarding population, rice, production and food consumption have been borrowed from statistical abstracts of Orissa (3). The data regarding the road distance among the district Headquarters was taken from the Department of P. W.D. (R and B) and transportation cost was calculated at the rate of 60 paisa/tonne/km. which is largely prevailing in the transportation market in Orissa. The basic data have been arranged systematically in the Table Nos. 1,2,3 and 4 which would be utilised to work out the system designs.

Table 1 Rice Production in Orissa

| District | Total area sown (000 hect.) | Area under paddy (000 hect.) | Total rice production ( 000 tonnes) |
|---|---|---|---|
| Balasore | 588 | 399 | 384 |
| Bolangir | 519 | 277 | 257 |
| Cuttack | 1186 | 521 | 438 |
| Dhenkanal | 515 | 261 | 278 |
| Ganjam | 754 | 292 | 420 |
| Kalahandi | 695 | 272 | 233 |
| Keonjhar | 344 | 205 | 189 |
| Koraput | 487 | 340 | 390 |
| Mayurbhanj | 504 | 362 | 206 |
| Phulbani | 293 | 84 | 96 |
| Puri | 767 | 388 | 410 |
| Sambalpur | 734 | 503 | 569 |
| Sundargarh | 280 | 212 | 107 |

Table 2. Rice Consumption in Orissa

| District | Total population (thousands) | Annual food consumption ( 000 tonnes) | Total rice consumption (000 tonnes) |
|---|---|---|---|
| Balasore | 2253.1 | 429.66 | 342.0 |
| Bolangir | 1425.6 | 277.00 | 221.0 |
| Cuttack | 4617.75 | 880.66 | 702.0 |
| Dhenkanal | 1576.57 | 300.65 | 239.0 |
| Ganjam | 2652.7 | 505.9 | 403.0 |
| Kalahandi | 1329.78 | 253.6 | 202.0 |
| Keonjhar | 1109.75 | 221.6 | 168.0 |
| Koraput | 2467.33 | 470.5 | 375.0 |
| Mayurbhanj | 1576.99 | 300.0 | 240.0 |
| Phulbani | 712.78 | 135.9 | 108.0 |
| Puri | 2911.72 | 555.26 | 443.0 |
| Sambalpur | 2274.12 | 433.7 | 346.0 |
| Sundargarh | 1336.82 | 254.81 | 203.0 |

Table -3 Surplus/Demand of Rice in Orissa

| District | Total Production (000 tonnes) | Import out of state (000 tones) | Total Consumption (000 tonnes) | Surplus/ demand (000 tonnes) |
|---|---|---|---|---|
| Balasore | 384 | - | 342 | +42 |
| Bolangir | 257 | - | 221 | +36 |
| Cuttack | 438 | 15 | 702 | -249 |
| Dhenkanal | 278 | - | 239 | +39 |
| Ganjam | 420 | - | 403 | +17 |
| Kalahandi | 233 | - | 202 | +31 |
| Keonjhar | 189 | - | 168 | +21 |
| Koraput | 390 | - | 375 | +15 |
| Mayurbhanj | 206 | - | 240 | -34 |
| Phulbani | 96 | - | 108 | -12 |
| Puri | 410 | - | 443 | -33 |
| Sambalpur | 569 | - | 346 | +223 |
| Sundergarh | 107 | - | 203 | -96 |

## STANDARD METHODS OF RICE DISTRIBUTION SYSTEM

1. North-West Corner Method (NWCM)

Procedure : The data for availability of rice in thousand tonnes taken from surplus districts and requirement of rice in thousand tonnes from deficit districts have been rearranged in Table No. 5. The tranportation cost per tonne was also put alongwith. The last row and last column are collectively called the rim conditions of the problem. The allocation of rice for the required stock of the deficit has been tried to be taken from the surplus district at first at the full capacity. If surplus stock of the districts does not fulfill the total required demand, then an additional stock has been allocated from the next surplus district and so on. If after fulfilling the total required demand, some surplus is remained in first surplus district, then the quantity has been allocated to the next deficit district. By this process all deficit district have been allocated quantity of rice from the surplus districts. The whole process of allocated goes from North to West. Then the allocated quantity are filled in the Table (5) and the transportation cost for rice from surplus to deficit districts has been calculated as given below.

Table - 4 Road Distance and Transportation Charges in Orissa.

| Districts | | Cuttack | Puri | Balaso-re | Gunjam | Dhenka-nal | Kala-handi | Phul-bani | Kora-put. | Mayur-bhanj | Sunder-garh. | Sambal-pur. | Keon-jhar | Bolang-gir |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cuttack | RD | 0 | 90 | 185 | 205 | 70 | 455 | 250 | 545 | 245 | 375 | 295 | 205 | 355 |
| | TC | 0 | 54 | 111 | 123 | 42 | 273 | 150 | 327 | 147 | 225 | 177 | 123 | 213 |
| Puri | RD | 90 | 0 | 275 | 240 | 155 | 490 | 280 | 580 | 330 | 465 | 380 | 295 | 385 |
| | TC | 54 | 0 | 165 | 144 | 93 | 294 | 168 | 348 | 198 | 279 | 228 | 177 | 231 |
| Balasore | RD | 185 | 275 | 0 | 395 | 210 | 635 | 435 | 735 | 60 | 520 | 435 | 245 | 540 |
| | TC | 111 | 165 | 0 | 237 | 126 | 381 | 261 | 441 | 36 | 312 | 261 | 147 | 324 |
| Ganjam | RD | 205 | 240 | 395 | 0 | 280 | 345 | 160 | 340 | 455 | 550 | 465 | 415 | 315 |
| | TC | 123 | 244 | 237 | 0 | 168 | 207 | 96 | 204 | 273 | 330 | 279 | 249 | 189 |
| Dhenkanal | RD | 70 | 155 | 210 | 280 | 0 | 395 | 320 | 550 | 275 | 305 | 220 | 235 | 285 |
| | TC | 42 | 93 | 126 | 168 | 0 | 237 | 192 | 330 | 165 | 183 | 132 | 141 | 171 |
| Kalahandi | RD | 455 | 490 | 635 | 345 | 395 | 0 | 250 | 180 | 705 | 335 | 245 | 625 | 110 |
| | TC | 273 | 294 | 381 | 207 | 237 | 0 | 150 | 108 | 423 | 201 | 147 | 375 | 66 |
| Phulbani | RD | 250 | 280 | 435 | 160 | 320 | 250 | 0 | 410 | 595 | 395 | 305 | 455 | 170 |
| | TC | 150 | 168 | 261 | 96 | 192 | 150 | 0 | 246 | 357 | 237 | 183 | 273 | 102 |
| Koraput | RD | 545 | 580 | 735 | 340 | 550 | 180 | 410 | 0 | 775 | 400 | 315 | 640 | 285 |
| | TC | 327 | 348 | 441 | 204 | 330 | 108 | 246 | 0 | 465 | 240 | 189 | 384 | 171 |

| Districts | | Cuttack | Puri | Balaso-re | Gunjam | Dhenka-nal | Kala-handi | Phul-bani | Kora-put. | Mayur-bhanj | Sunder-garh. | Sambal-pur. | Keon-jhar | Bolang-gir |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mayurbhanj | RD | 245 | 330 | 60 | 455 | 275 | 705 | 595 | 775 | 0 | 575 | 490 | 175 | 605 |
| | TC | 147 | 198 | 36 | 273 | 165 | 423 | 357 | 465 | 0 | 345 | 294 | 105 | 363 |
| Sundergarh | RD | 375 | 465 | 520 | 550 | 305 | 335 | 395 | 400 | 576 | 0 | 85 | 130 | 225 |
| | TC | 225 | 279 | 312 | 330 | 183 | 201 | 237 | 240 | 345 | 0 | 51 | 78 | 135 |
| Sambalpur | RD | 295 | 380 | 435 | 465 | 220 | 245 | 305 | 315 | 490 | 85 | 0 | 195 | 140 |
| | TC | 177 | 228 | 261 | 279 | 132 | 147 | 183 | 189 | 294 | 51 | 0 | 117 | 84 |
| Keonjhar | RD | 205 | 295 | 245 | 415 | 235 | 625 | 425 | 640 | 175 | 130 | 195 | 0 | 315 |
| | TC | 123 | 177 | 145 | 249 | 141 | 375 | 273 | 384 | 105 | 78 | 117 | 0 | 195 |
| Balangir | RD | 355 | 385 | 540 | 315 | 285 | 110 | 170 | 285 | 605 | 225 | 140 | 325 | 0 |
| | TC | 213 | 231 | 324 | 189 | 171 | 66 | 102 | 171 | 363 | 135 | 84 | 195 | 0 |

RD : Shortest road distance in kilometers : taken from Deptt. of P.W.D. (R and D), Orissa
TC : Transportation cost in Rs./ton. at the rate of 60 paise/tonne/kilometer.

Table 5 Rice Distribution and Transportation Cost.

| From/To | Cuttack | | Mayurbhanj | | Phulabani | | Puri | | Sundergarh | | Available (000 tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | AC | TC | AC | TC | AC | TC | AC | TC | AC | TC | |
| Balasore | 42 | 111 | - | 36 | - | 261 | - | 165 | - | 312 | 42 |
| Bolangir | 36 | 213 | - | 363 | - | 102 | - | 231 | - | 135 | 36 |
| Dhenkanal | 39 | 42 | - | 165 | - | 192 | - | 93 | - | 183 | 39 |
| Ganjam | 70 | 123 | - | 273 | - | 96 | - | 144 | - | 330 | 17 |
| Kalahandi | 31 | 273 | - | 423 | - | 150 | - | 294 | - | 201 | 31 |
| Keonjhar | 21 | 123 | - | 105 | - | 273 | - | 177 | - | 78 | 21 |
| Koraput | 15 | 327 | - | 465 | - | 246 | - | 348 | - | 240 | 15 |
| Sambalpur | 48 | 177 | 34 | 294 | 12 | 183 | 33 | 228 | 96 | 51 | 223 |
| Requirement(000 tonnes) | 249 | | 34 | | 12 | | 33 | | 96 | | 424 |

AC: Quantity alocated in thousand tonnes.
TC. Transportation cost per tonne (rupees)

Calculation of Minimum Cost of Transportation (NWCM)

| Sl.No. | Quantity allocated (tonnes) | Transportation cost (Rs./tonne) | Total cost (Rs.) |
|---|---|---|---|
| 1. | 42,000 | 111.00 | 46,62.000 |
| 2. | 36,000 | 213.00 | 76,68,000 |
| 3. | 39,000 | 42.00 | 16,38,000 |
| 4. | 17,000 | 123.00 | 20,91,000 |
| 5. | 31,000 | 273.00 | 84,63,000 |
| 6. | 21,000 | 123.00 | 25,83,000 |
| 7. | 15,000 | 327.00 | 49,05,000 |
| 8. | 48,000 | 177.00 | 84,96,000 |
| 9. | 34,000 | 294.00 | 99,96,000 |
| 10. | 12,000 | 183.00 | 21,96,000 |
| 11. | 33,000 | 228.00 | 75,24,000 |
| 12. | 96,000 | 51.00 | 48,96,000 |
| | | Total Cost | 6,51,18,000. |

2. *Minimum Cell Method (MCM)*

Procedure : Fill the data for requirement, availability and transportation cost in the Table No. 6. Select the column of minimum costs and put the required quantity from the available column. Try to allocate the requirement from the available stock. Then select another second higher transportation cost among the rest minimum costs and do the similar job. The total of the partial requirement and assigned quanitity should be equal to the whole quantity. This process of allocation in relation to the minimum costs to the increasingly higher is called minimum cell method. After allocation, calculate the transportation costs for all assigned quantities in the cells as given below :

Table : 6 Rice Allocation and Transportation costs (MCM)

| From/To | Cuttack | | Mayurbhanj | | Phulbani | | Puri | | Sundergarh | | Available (000 tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | AC | TC | AC | TC | AC | TC | AC | TC | AC | TC | |
| Balasore | 8 | 111 | 34 | 36 | - | 261 | - | 165 | - | 312 | 42 |
| Bolangir | 36 | 213 | - | 363 | - | 102 | - | 231 | - | 135 | 36 |
| Dhenkanal | 39 | 42 | - | 165 | - | 192 | - | 93 | - | 183 | 39 |
| Ganjam | 5 | 123 | - | 273 | 12 | 96 | - | 144 | - | 330 | 17 |
| Kalhandi | 13 | 273 | - | 423 | - | 150 | 18 | 294 | - | 201 | 31 |
| Keonjhar | 21 | 123 | - | 105 | - | 273 | - | 177 | - | 78 | 21 |
| Koraput | 15 | 327 | - | 465 | - | 246 | - | 348 | - | 240 | 15 |
| Sambalpur | 112 | 177 | - | 294 | - | 183 | 15 | 228 | 96 | 51 | 223 |
| Requirement (000 tonnes) | 249 | | 34 | | 12 | | 33 | | 96 | | 424 |

Calculation of Minimum Cost of Transportation (MCM)

| Sl.No. | Quantity allocated (tonnes) | Transportation cost (Rs./tonne) | Total cost (Rs.) |
|---|---|---|---|
| 1. | 8,000 | 111.00 | 8,88,000 |
| 2. | 36,000 | 213.00 | 76,68,000 |
| 3. | 39,000 | 42.00 | 16,38,000 |
| 4. | 5,000 | 123.00 | 6,15,000 |
| 5. | 13,000 | 273.00 | 35,49,000 |
| 6. | 21,000 | 123.00 | 25,83,000 |

| | | | |
|---|---|---|---|
| 7. | 15,000 | 327.00 | 49,05,000 |
| 8. | 1,12,000 | 177.00 | 1,98,24,000 |
| 9. | 34,000 | 36.00 | 12,24,000 |
| 10. | 12,000 | 96.00 | 11,52,000 |
| 11. | 18,000 | 294.00 | 52,92,000 |
| 12. | 15,000 | 228.00 | 34,20,000 |
| 13. | 96,000 | 51.00 | 48,96,000 |
| | | Total Cost : | 5,76,54,000 |

3. *Vogall Approximation Method (VAM)*

Procedure : Fill the data of requirement and availability in TableNo. 7. Substract the lowest transportation cost from all figures of the cells. Determine the difference between the two lowest costs for each row and column. Select the row/column with the greatest diference between the two lowest figures of the cost, Assign the largest possible allocation within the cosntraints to the lowest cost square in a row or column selected. Cross out any row or column completely in the above mentioned step. Recaluculate the difference as given before except for rows and column which have been crossed out. Repeat the process for all steps until all assignments are made. Then calculate the transportation costs for the last allocated quantities. As this method gives nearly lowest cost so this is very powerful method of the system.

Table : 7 VAM Allocation and Transportation Cost

| | | | | | |
|---|---|---|---|---|---|
| Difference between two lowest cost | 69,69, 69,81 | 69,69, 69 | 6,6 | 51,51, 51,51 | 27 |

| From/To | Cuttack | | Mayur-bhanj | | Phulbani | | Puri | | Sundergarh | | Available (000 tonnes) | Differ-ence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AC | TC | AC | TC | AC | TC | AC | TC | AC | TC | | |
| Balasore | 8 | 75 | 34 | 0 | - | 225 | - | 129 | - | 276 | 42 | 75,75,75 |
| Bolangir | 18 | 177 | - | 327 | - | 66 | 18 | 195 | - | 99 | 36 | 33,111, 18,18,18 |
| Dhenkanal | 39 | 6 | - | 129 | - | 156 | - | 57 | - | 147 | 39 | 51,51, 51,51 |
| Ganjam, | 17 | 87 | - | 237 | - | 60 | - | 108 | - | 294 | 17 | 27,27 21,21 |
| Kalanhandi | 19 | 237 | - | 387 | 12 | 114 | - | 258 | - | 165 | 31 | 21,123 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Keonjhar | 21 | 87 | - | 69 | - | 237 | - | 141 | - | 42 | 21 | 27,18 18,54 |
| Koraput | - | 291 | - | 429 | - | 210 | 15 | 312 | - | 204 | 15 | 6,84, 18,18 |
| Sambalpur | 127 | 141 | - | 258 | - | 147 | - | 192 | 96 | 15 | 223 | 126 |
| Requirement (000 tonnes) | 249 | | 34 | | 12 | 33 | | 96 | | 424 | | |

Calculation of Minimum Cost of Transportation (VAM)

| Sl.No. | Quantity allocated (tonnes) | Transpoortation cost (Rs./tonne) | Total cost (Rs.) |
|---|---|---|---|
| 1. | 8,000 | 111.00 | 888,000 |
| 2. | 18,000 | 213.00 | 3834,000 |
| 3. | 39,000 | 42.00 | 1638,000 |
| 4. | 17,000 | 123.00 | 2091,000 |
| 5. | 19,000 | 273.00 | 5187,000 |
| 6. | 21,000 | 123.00 | 583,000 |
| 7. | 127,000 | 177.00 | 2,2479,000 |
| 8. | 34,000 | 36.00 | 1224,000 |
| 9. | 12,000 | 150.00 | 1800,000 |
| 10. | 18,000 | 231.00 | 4158,000 |
| 11. | 15,000 | 348.00 | 5220,000 |
| 12. | 96,000 | 51.00 | 4896,000 |
| | | Total cost | Rs. 5,59,98,000 |

4. Modified Distribution Method (Modi)

Procedure : Refer to VAM No. 7 for assigned value and table No.6 for cost of transportation. Use modi theoritical standard equation R+K+C = 0 to calculate the values of index constants R,K, and C for the closed squares. Then use these calculated value of constants to find out the result values for the open squares. Judge any improvement in the allocations from the result values. If there come any one or more result value to be negative, select the greatest negative value if there are more than one negative value. Then by selection of the square having higher negative value, think for the improvement in the allocation for that squares. Select a close rectangular path of the squares having assigned

values, then add something (say 2) in the quantity for that square to have improvement in the allocation. Then go on substracting, adding and substracting 2 to all assigned value at corner squares respectively to fulfill the rim conditions. Recalculate the values of R and K and re-examine the open squares. Repeat the process until we have no negative value. After re-arranging the values, calculate the cost of transportation.

Then put all these calculated values of R and K in the squares attached in Table No.8 use these calculated values for the open squaresto know the improvement. If last result value comes negative for a particular open square, then that square needs some improvement. Use the standard equation R+K+C = 0.

Table 8 Modi System of allocation

| Value of K | K1 = -111 | K2 =-36 | | K3=12 | | K4=-129 | | K5=15 |
|---|---|---|---|---|---|---|---|---|
| Value of R | From/To | Cuttack | Mayur-bhanj | Phulbani | Puri | Sundar-garh. | | Available (000tonnes) |
| | | AC TC | AC TC | AC TC | AC TC | AC TC | | |
| $R_1$=0 | Balasore | 8 111 | 34 36 | - 261 | - 165 | - 312 | | 42 |
| $R_2$=-102 | Bolangir | 18 213 | - 363 | - 102 | 18 231 | - 135 | | 36 |
| $R_3$=69 | Dhenkanal | 39 42 | - 165 | - 192 | - 93 | - 183 | | 39 |
| $R_4$=-12 | Ganjam | 17 123 | - 273 | - 96 | - 144 | - 330 | | 17 |
| $R_5$=-162 | Kalahandi | 19 273 | - 423 | 12 150 | - 294 | - 201 | | 31 |
| $R_6$=-12 | Keonjhar | 21 123 | - 105 | - 273 | - 177 | - 78 | | 21 |
| $R_7$=-219 | Koraput | - 327 | - 465 | - 246 | 15 348 | - 240 | | 15 |
| $R_8$=-66 | Sambalpur | 127 177 | - 294 | - 183 | - 228 | 96 51 | | 223 |
| Requirement (000 tonnes) | | 249 | 34 | 12 | 33 | 96 | | 424 |

R= Index number for row, K=Index number for column and

C= Index number for cost

As we know the standard equation R+K+C=0. By using this equation calculate the values of R and K for closed squares. Assume the value fo $R_1$=0 at the beginning of the calculation.

| Closed square (Row, column) | Calculations R+K+C=0 | Result value of R/K |
|---|---|---|
| 1,1 | $R_1+K_1+C_{11}=0$ | 0+K1+111=0 $K_1$=-111 |
| 1,2 | $R_1+K_2+C_{12}=0$ | 0+K2+36=0 $K_2$=-36 |

| | | | |
|---|---|---|---|
| 2,1 | $R_2+K_1+C_{21}=0$ | $R_2-111+213=0$ | $R_2=-129$ |
| 2,4 | $R_2+K_4+C_{24}=0$ | $-102+K_4+231=0$ | K4=-129 |
| 3,1 | $R_3+K_1+C_{31}=0$ | $R_3-111+42=0$ | $R_3=+69$ |
| 1,1 | $R_4+K_1+C_{41}=0$ | $R_4-111+123=0$ | $R_4=-12$ |
| 5,1 | $R_5+K_1+C_{51}=0$ | R5-111+273=0 | $R_5=-162$ |
| 5,3 | $R_5+K_3+R_{53}=0$ | $-162+K_3+150=0$ | $K_3=+12$ |
| 6,1 | $R_6+K_1+R_{61}=0$ | $R_6-111+123=0$ | $R_6=-12$ |
| 7,4 | $R_7+K_4+R_{74}=0$ | $R_7-129+348=0$ | $R_7=-219$ |
| 8,1 | $R_8+K_1+R_{81}=0$ | $R_8-111+177=0$ | $R_8=-66$ |
| 8,5 | $R_8+K_5+R_{85}=0$ | $-66+K_5+51=0$ | $K_5=+15$ |

| Open Square (Row, Column) | Result value | | Decission for improvement |
|---|---|---|---|
| 1,3 | $R_1+K_3+C_{13}=0$ | O+12-261=273 | No improvement |
| 1,4 | $R_1+K_4+C_{14}=0$ | O-129+165=36 | -do- |
| 1,5 | $R_1+K_5+C_{15}=0$ | O+15+312=327 | -do- |
| 2,2 | $R_2+K_2+C_{22}=0$ | -102-36+363=225 | -do- |
| 2,3 | $R_2+K_3+C_{23}=0$ | -102+12+102=12 | -do- |
| 2,5 | $R_2+K_5+C_{25}=0$ | -102+15+135=48 | do |
| 3,2 | $R_3+K_2+C_{32}=0$ | 69-36+165=198 | do |
| 3,3 | $R_3+K_3+C_{33}=0$ | 69+12+192=273 | do |
| 3,4 | $R_3+K_4+C_{34}=0$ | 69-129+93=33 | do |
| 3,5 | $R_3+K_5+C_{35}=0$ | 69+15+183=267 | do |
| 4,2 | $R_4+K_2+C_{42}=0$ | -12-36+273=225 | do |
| 4,3 | $R_4+K_3+C_{43}=0$ | -12+12+96=96 | do |
| 4,4 | $R_4+K_4+C_{44}=0$ | -12-129+144=3 | do |
| 4,5 | $R_4+K_5+C_{45}=0$ | -12+15+330=333 | do |
| 5,2 | $R_5+K_2+C_{52}=0$ | -162-36+423=225 | do |
| 5,4 | $R_5+K_4+C_{54}=0$ | -162-129+294=3 | do |
| 5,5 | $R_5+K_5+C_{55}=0$ | -162+15-201=54 | do |
| 6,2 | $R_6+K_2+C_{62}=0$ | -12-36+105=57 | do |
| 6,3 | $R_6+K_3+C_{63}=0$ | -12+12+273=273 | do |
| 6,4 | $R_6+K_4+C_{64}=0$ | -12-129+177=36 | do |
| 6,5 | $R_6+K_5+C_{65}=0$ | -12+15+78=81 | do |
| 7,1 | $R_7+K_1+C_{71}=0$ | -219-111+327=-3 | Needs improvement |
| 7,2 | $R_7+K_2+C_{72}=0$ | -219-36+465=210 | No improvement |
| 7,3 | $R_7+K_3+C_{73}=0$ | -219+12+246=39 | do |
| 7,5 | $R_7+K_5+C_{75}=0$ | -219+15+240=36 | do |
| 8,2 | $R_8+K_2+C_{82}=0$ | -66-36+294=192 | do |
| 8,3 | $R_8+K_3+C_{83}=0$ | -66+12+183=129 | do |
| 8,4 | $R_8+K_4+C_{84}=0$ | -66-129+228=33 | do |

Out of these 28 open squares, only one square (7,1) needs improvement. Now prepare the table No. 9 for the improved allocation of the values.

Table-9 Improved Allocation (Modi)

| Value of K/R | K1 AC TC | K2 AC TC | K3 AC TC | K4 AC TC | K5 AC TC | Available (000 tonnes) |
|---|---|---|---|---|---|---|
| R1 | 8 111 | 34 36 | - 261 | - 165 | - 312 | 42 |
| R2 | 18 213 -2=16 | - 363 | - 102 | 18 231 +2=20 | - 135 | 36 |
| R3 | 39 42 | - 165 | - 192 | - 93 | - 183 | 39 |
| R4 | 17 123 | - 273 | - 96 | - 144 | - 330 | 17 |
| R5 | 19 273 | - 423 | 12 150 | - 294 | - 201 | 31 |
| R6 | 21 123 | - 105 | - 273 | - 177 | - 78 | 21 |
| R7 | - 327 +2=2 | - 465 | - 246 | 15 348 -2=13 | - 240 | 15 |
| R8 | 127177 | - 294 | - 183 | - 228 | 96 51 | 223 |
| Requirement (000 tonnes) | 249 | 34 | 12 | 33 | 96 | 424 |

## RESULTS AND DISCUSSION

All the four distribution systems are efficient giving minimum cost of transportation for all types of goods from ome place to other. The cost of transportation for rice from surplus districts to the deficit districts of Orissa worked out to be Rs. 6,51,18,000 by North-west corner method, Rs. 5,76,54,000 by Minimum Cell Method, Rs. 5,59,98,000 by Vogal Approximation Method, and Rs. 5,59,92,000 by Modified Distribution Method. By judging all the above costs of transportation, the last two methods seem to be more powerful and efficient. Though the modified distribution method is lengthy and laborius it is the cheapest method of transportation. The four methods may be used for any type of scientific planning for transfer of goods from one place to other in any organisation, state and country including civil and defence areas.

Calculation of Miinimum Cost of Transportation (Modi)

| Sl.No. | Quantity allocated (000 tonnes) | Transportationcost (Rs./tonne) | Totalcost (Rs.) |
|---|---|---|---|
| 1. | 18,000 | 111.00 | 888,000 |
| 2. | 16,000 | 213.00 | 3408,000 |

| | | | |
|---|---|---|---|
| 3. | 39,000 | 42.00 | 1638,000 |
| 4. | 17,000 | 123.00 | 2091,000 |
| 5. | 19,000 | 273.00 | 5187,000 |
| 6. | 21,000 | 123.00 | 2583,000 |
| 7. | 127,000 | 177.00 | 2,2479,000 |
| 8. | 2,000 | 327.00 | 654,000 |
| 9. | 34,000 | 36.00 | 1224,000 |
| 10. | 12,000 | 150.00 | 1800,000 |
| 11. | 20,000 | 231.00 | 4620,000 |
| 12. | 13,000 | 348.00 | 4524,000 |
| 13. | 96,000 | 51.00 | 4896,000 |
| | | Total cost: | 5,59,92,000 |

## CONCLUSION AND RECOMMENDATIONS

These four well experienced methods of transportation are most efficeint and cheap for transfer of all kind of materials like coal, cement, minerals, stones, steel and agricultural products etc. from production point to the consumption point. These methods may be applied in any organisation for transfer of any type of product giving lowest cost of transportation. The Vogall Approximation Method and Modified Distribution Method are most powerful methods and so may be used for any type of trasnportation planning.

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