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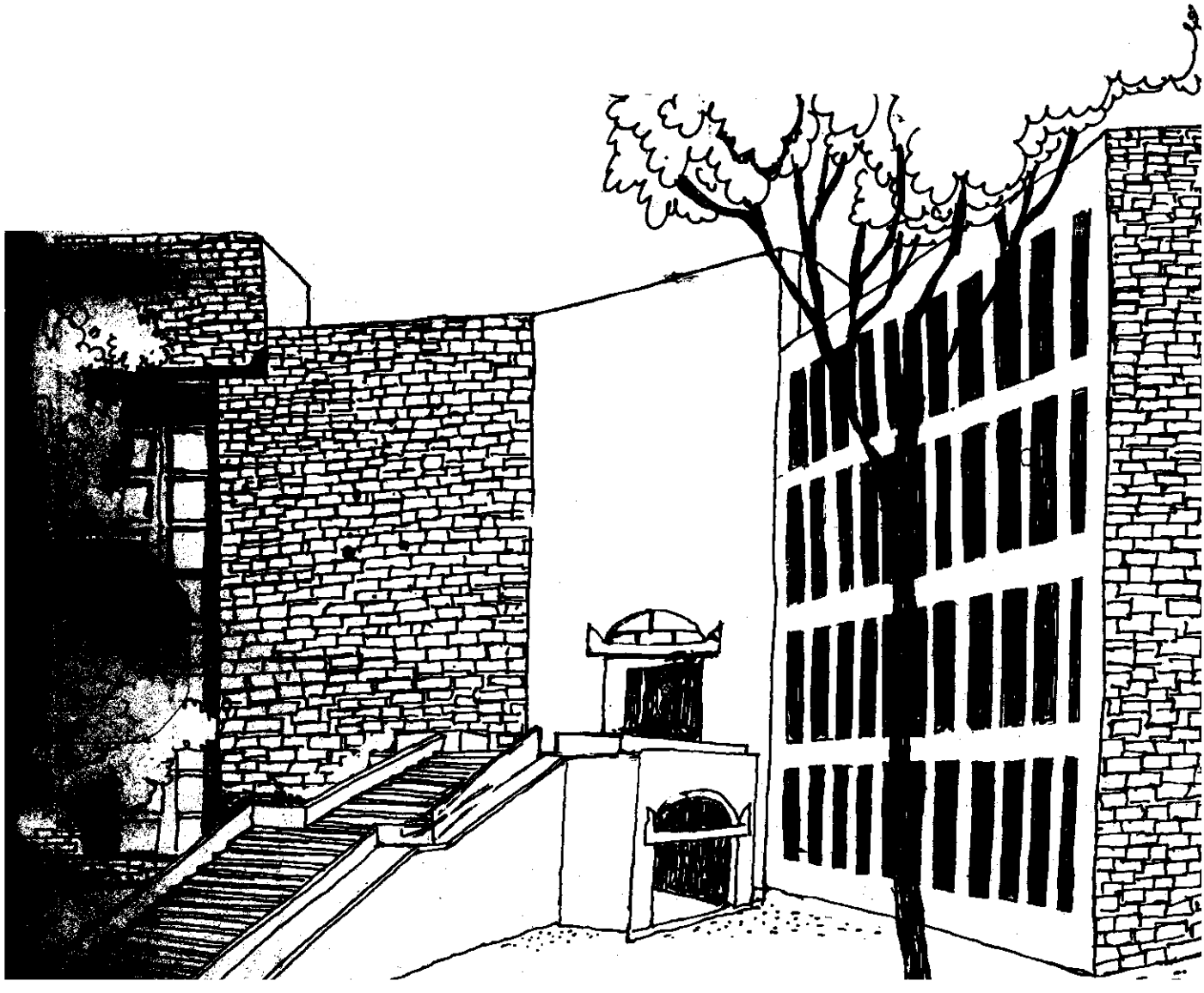

DEVELOPING LINEAR PROGRAMMING MODELS FOR FARM PLANNING

By

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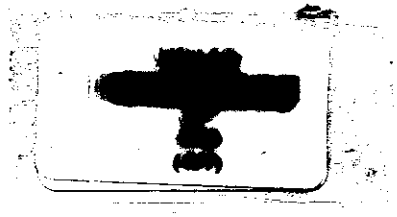

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DEVELOPING LINEAR PROGRAMMING MODELS FOR FARM PLANNING

1 INTRODUCTION

Plethora of research and other literature on application of linear programming in farm planning is available where the authors have tried to maximise/minimise the objective function under the given sets of constraints and feasible allocative activities. Though identification and estimation of constraints and requirements, identification of feasible activities, estimation of input-output coefficients including objective function values are essential operations in constructing a linear programming model, these are rarely adequately emphasised. The authors perhaps assumed that their readers either have adequate knowledge of these operations or they are not interested in such details. Another apprehension with the authors could be the space these details would have reserved. Nevertheless, these are useful in understanding the rationale behind the selection of constraints, activities and their coefficients, and the manner in which these are represented or modelled.

Our attempt in this paper, therefore, is to describe the methodology of developing the above mentioned components of linear programming model for common run farms in an agriculturally homogeneous area. The model includes all the constraints and the activities relevant for bullock and tractor operated farms. For more precise results the farms could be grouped on the basis of operational size and extent of mechanisation, etc., and separate model developed for each group. It may, however, be noted that the nature of resource constraints and consumption requirements is identical on all those

farms. Also, because of neutrality of input technology to size, optimum input-output coefficients for a crop do not change among the farms. The only differences are the replacement of bullock power and attached labour by tractor power and attached labour, and added costs on fuel, etc. due to tractor cultivation. Therefore, on tractor farms we have additional constraints of tractor power and modified constraints of labour and input costs. Since surplus tractor power can be hired out additional constraints of custom hiring, tractor are included. Some other differences in constraints, activities, and the input-output coefficients among the farms are discussed at relevant places. The constraints and activities specific to certain category of farms are clearly indicated in the model. The model is made flexible to incorporate changes in constraints, consumption requirements, and various arrangements for their supply as well as for disposal of output. The model may be modified for specific situations by dropping some constraints and activities not relevant for the situation and by using appropriate values of constraints and some input output coefficients specific to the situation.

2 THE MODEL

The generalised linear programming model for profit maximisation can be presented as follows:

$$\text{Maximise } Z = \sum_{i=1}^{n} P_i X_i$$

$$\text{Subject to } C_j \quad \sum_{i=1}^{n} a_{ij} X_i$$

$$\text{and} \quad X_i \quad 0$$

Where Z is the objective function to be maximised, Pi and Xi, respectively, are net cash flows from and level of ith activity, Cj is the level of jth constraint and a_{ij} is the coefficient of jth constraint for ith activity.

Having differing financial environment, investment levels and liquidity sources the farmers as decision makers respond differently to the choices available to them in production, consumption, marketing, financing and investment. The ultimate goal of maximising net cash flow is, however, common for all. As such the linear programming model, discussed in the following sections, includes production, consumption, marketing, financing and investment components. The objective function is to maximise the net cash flows from a unique combination of activities feasible on the farms subject to the limitations of availability of land, FYM, labour, draft power, irrigation, cash, credit (cash and kind); and minimum consumption, cash reserve and liquidity reserve requirements. The model is constructed for a planning horizon of one agricultural year with two crop seasons. Optimum input-output coefficients are computed from the recommended practices for different crop enterprises at given prices. The coefficients for liquidity requirements represent the risk values attached to individual activities.

3. OBJECTIVE FUNCTION

The objective function to be maximised in the model is the sum of net cash flows at the end of the reference year. It is the simple summation of income transferred and the value of cash and credit reserves activated in the process. As the reserves are not realised

income their values should be subtracted from the objective function value in the interpretation of the latter. The objective function (Z) is represented by a row vector in the linear programming model.

4 CONSTRAINTS AND REQUIREMENTS

The list of constraints of resource availabilities and consumption requirements along with RHS values for a farm situation may be given as in Table 1. The table also gives the row identification abbreviations, units of measurement and the RHS relationships. The abbreviation LE stands for "less than or equal to" constraints, GE for "greater than or equal to" requirements and EQ for equality restrictions. These constraints and requirements are represented by a column vector in the linear programming model.

4.1 Land Constraints (Rows 1 to 5)

Land constraints may either be represented separately for owned land and leased in land or together as operated area. In the former case alternative leasing arrangements may be incorporated through separate activities. This represents the reality more precisely as only the operator's share in the net income generated from share lease is transfered to the objective function. Rows 1 and 2 refer to the acres of owned land available in the kharif and rabi crop seasons, respectively.

Table 1: Resource Constraints and Consumption Requirements on Large Bullock (LB) a Tractor (LT) Farms in Central Punjab, 1977-78

Row No.	Constraints and Requirements	Units	Row ID	LE/ GE/ EQ	RHS Values	
					LB	LT
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Land Kharif	Acres	LNDK	LE	22.2	31.6
2	Land Rabi	Acres	LNDR	LE	22.2	31.6
3	Lease in Land Maximum	Acres	LIMX	LE	3.9	4.2
4	Share Lease in Land Use Kharif	Acres	SLUK	EQ	0	0
5	Share Lease in Land Use Rabi	Acres	SLUR	EQ	0	0
6	Farm Yard Manure Kharif	Tonne	FYMK	EQ	35	40
7	Farm Yard Manure Rabi	Tonne	FYMR	LE	35	40
8	Labour 1 (Mid June-Mid August)	Hours	LAB1	LE	1360	2000
9	Labour 2 (Mid August-October)	Hours	LAB2	LE	1760	2520
10	Labour 3 (November-Mid January)	Hours	LAB3	LE	1760	2520
11	Labour 4 (Mid January-March)	Hours	LAB4	LE	1760	2520
12	Labour 5 (March-Mid June)	Hours	LAB5	LE	1760	2520
13	Labour 6 (Picking Labour)	Hours	LAB6	LE	590	590
14	Bullock 1 (June-July)	Hours	BLK1	LE	615	-
15	Bullock 2 (Mid October-December)	Hours	BLK2	LE	925	-
16	Bullock 3 (April-May)	Hours	BLK3	LE	615	-
17	Bullock Total	Hours	BLKT	LE	4170	-
18	Tractor 1 (June-July)	Hours	TRC1	LE	-	240
19	Tractor 2 (November-December)	Hours	TRC2	LE	-	240
20	Tractor Total	Hours	TRCT	LE	-	1000
21	Irrigation 1 (July-August)	Hours	IRR1	LE	480	630
22	Irrigation 2 (November-December)	Hours	IRR2	LE	480	630
23	Irrigation 3 (January-March)	Hours	IRR3	LE	720	945
24	Irrigation Use Total	Hours	IRRT	LE	0	0
25	Thresher Kharif	Hours	THRK	LE	144	160
26	Thresher Rabi	Hours	THRR	LE	216	240
27	Cane Crusher	Hours	CCRS	LE	288	288
28	Maize Sheller	Hours	MZSL	LE	0	72
29	Kharif Capital Inputs (A)	Rs.	KCIA	EQ	0	0
30	Kharif Capital Inputs (B)	Rs.	KCIB	EQ	0	0
31	Rabi Capital Inputs (A)	Rs.	RCIA	EQ	0	0
32	Rabi Capital Inputs (B)	Rs.	RCIB	EQ	0	0
33	Total Cereals Requirements	Kgs.	TCRQ	EQ	1920	1960

Table 1: Cont...

(1)	(2)	(3)	(4)	(5)	(6)	(7)
34	Maize Production and Disposal	Kgs.	MZPD	EQ	0	0
35	Bajra Production and Disposal	Kgs.	BJPD	EQ	0	0
36	Rice Production and Disposal	Kgs.	RCPD	EQ	0	0
37	Wheat Production and Disposal	Kgs.	WTPD	EQ	0	0
38	Kharif Pulses Requirements	Kgs.	KPRQ	EQ	32	34
39	Rabi Pulses Requirements	Kgs.	RPRQ	EQ	32	34
40	GUR Requirements	Kgs.	GRRQ	EQ	400	400
41	KADABI Requirements	Qtls.	KDRQ	EQ	70	70
42	BHUSA Requirements	Qtls.	BSRQ	EQ	100	100
43	Kharif Feed Requirements	0'Kgs.	KFRQ	EQ	25	25
44	Rabi Feed Requirements	0'Kgs.	RFRQ	EQ	25	25
45	Barley Production and Disposal	0'Kgs.	BLPD	EQ	0	0
46	Gram Production and Disposal	0' Kgs.	GMPD	EQ	0	0
47	Cane Production and Disposal	Qtls.	CNPD	EQ	0	0
48	Consumption Needs for Cash Kharif	Rs.	CCNK	EQ	4750	5040
49	Consumption Needs for Cash Rabi	Rs.	CCNR	EQ	4750	5040
50	Liquidity Res. Requirement Kharif	Rs.	LRRK	GE	2300	4000
51	Liquidity Res. Requirement Rabi	Rs.	LRRR	GE	2300	4000
52	Cash Available Kharif	Rs.	CSAK	LE	10800	15740
53	Cash Available Rabi	Rs.	CSAR	EQ	0	0
54	Cash Use Kharif	Rs.	CSUK	EQ	0	0
55	Cash Use Rabi	Rs.	CSUR	EQ	0	0
56	Operating Cash Kharif	Rs.	OCSK	EQ	0	0

Table 1: Contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)
57	Operating Cash Rabi	Rs.	OCSR	EQ	0	0
58	Inst. Credit Available Kharif	Rs.	ICAK	LE	3120	4320
59	Inst. Credit Available Rabi	Rs.	ICAR	LE	3120	4320
60	Inst. Credit Use Kharif A	Rs.	ICUKA	EQ	0	0
61	Inst. Credit Use Kharif B	Rs.	ICUKB	EQ	0	0
62	Inst. Credit Use Rabi A	Rs.	ICURA	EQ	0	0
63	Inst. Credit Use Rabi B	Rs.	ICURB	EQ	0	0
64	Non-Inst. Credit Available Kharif	Rs.	NCAK	LE	2750	3700
65	Non-Inst. Credit Available Rabi	Rs.	NCAR	LE	2750	3700
66	Non-Inst. Credit Use Kharif	Rs.	NCUK	EQ	0	0
67	Non-Inst. Credit Use Rabi	Rs.	NCUR	EQ	0	0
68	Cash Income Kharif	Rs.	CINK	EQ	0	0
69	Cash Income Rabi	Rs.	CINR	EQ	0	0
70	Cash Reserve	Rs.	CRSV	EQ	0	0
71	Inst. Debt Repayment Kharif	Rs.	IDRK	EQ	0	0
72	Inst. Debt Repayment Rabi	Rs.	IDRR	EQ	0	0
73	Non-Inst. Debt Repayment Kharif	Rs.	NDRK	EQ	0	0
74	Non-Inst. Debt Repayment Rabi	Rs.	NDRR	EQ	0	0
75	Sugarcane Ratoon Maximum	Acres	SCMX	LE	3.35	2.55
76	Credit Purchases Maximum Kharif	Rs.	CPMK	LE	1490	1457
77	Credit Purchases Maximum Rabi	Rs.	CPMR	LE	1490	1457
78	Credit Potential Unactivated	Rs.	CPUN	LE	5880	4680
79	Tractor Hiring Out 1 (June-July)	Hours.	TCH1	LE	-	80
80	Tractor Hiring Out 2 (Nov. - Dec.)	Hours	TCH2	LE	-	80
81	Tractor Hiring Out Total	Hours	TCHT	LE	-	190
82	Thresher Hiring Out 1 (Kharif)	Hours	TRH1	LE	36	40
83	Thresher Hiring Out 2 (Rabi)	Hours	TRH2	LE	54	60
84	Green Fodder Minimum Kharif	Acres	FMNK	GE	3.00	3.00
85	Green Fodder Minimum Rabi	Acres	FMNR	GE	2.00	2.00
86	Tractor Purchase	No.	TCPR	GE	1	-
87	Thresher Purchase	No.	TRPR	GE	1	1
88	Maize Sheller Purchase	No.	MSPR	GE	1	1
89	Cane Crusher Purchase	No.	CRPR	GE	1	1
90	Pumpset Installation	No.	PSIN	GE	1	1
91	Maize Consumption Maximum	Kgs.	MCMX	LE	265	285
92	Bajra Consumption Maximum	Kgs.	BCMX	LE	159	171
93	Rice Consumption Maximum	Kgs.	RCMX	LE	53	57

As all the area is capable of double cropping and is irrigable, the RHSs for both the rows are equal. Those land constraints are relaxable by the area available to the cultivators on lease (equal to actually leased in area during previous year adjusted for any contingencies anticipated for the following year). The relationships with RHSs for these constraints are "less than or equal to".

Row 3 refers to the lease in land constraint introduced to restrict the leasing in of land. Any combination of the two arrangements of leasing is permitted subject to the limits imposed on total given as RHS. Constraints 4 and 5 guarantee the full use of land on share lease in the two seasons.

4.2 FYM Constraints (Rows 6 and 7)

The FYM availability is measured in tonnes. It is limited to domestic production during the respective season. However, unused FYM in kharif is permitted to be used in rabi season. Therefore the relationship with RHS for kharif row constraint is "equal to" and that for rabi row constraint it is "less than or equal to".

4.3 Labour Constraints (Rows 8 to 13)

The labour availability on a farm may be family labour and permanent hired labour. No distinction between the two is necessary as no division of jobs for the two categories is specified. Further female and child labour is employed for certain jobs and hence their availability may be represented by separate constraints.

Since labour is not storable, its availability cannot be transfered from one time period to the other. Therefore, labour availability may be represented by separate constraints for different periods determined on the basis of length of various operations. The finner these periods are, the more effective will the representation of these constraints be. In this exercise we have developed six labour constraints, namely, LAB1 to LAB6. The first five represent the male family and permanent hired labour availability in hours during five periods of the year. The sixth is the women family labour in hours for the cotton picking season. The RHS quantities are computed at 90 per cent of the total days of 60 for the first period and 70 for the each of the remaining four periods per worker. Each day is eight hours long. The picking period is assumed to be of 40 picking days. Each picking day consists of eight work hours for all except one women per household who is supposed to do the kitchen chores and for whom it is four work hours. The supply of labour may be supplemented by casual hiring.

4.4 Bullock Power Constraints (Rows 14 to 17)

These constraints are relevant for bullock operated farms mainly. Like human labour, bullock power is not storable and hence its availability in different periods is depicted by separate constraints. Bullock power was considered a constraint in two preparatory tillage periods and one harvesting period. BPR1, BPR2 and BPR3, respectively, represent the bullock power constraints for the three periods. The RHS is computed at 40, 60 and 40 working days of eight hours each during

respective periods. BPRT gives the total supply of bullock power during the year at the rate of 250 days or 2,000 hours per pair of bullocks.

4.5 Tractor Power Constraints (Rows 18 to 20)

Just like bullock power, tractor power availability is considered a constraint on tractor operated farms for the two soil preparation periods. The total working hours available are taken at 1,000 for the year, of which 240 hours are available during each of the two rush work periods, represented by TPR1 and TPR2. TPRT is the total tractor power available for the year. A part of the tractor power in different periods is permitted to be hired out with maximum upper limits.

4.6 Irrigation Capacity Constraints (Rows 21 to 24)

Irrigation capacity is measured in terms of hours of flow of water that could be produced from all sources of irrigation taken together. Three periods are considered when irrigation could become a constraint in the crop production process. They are kharif sowing period IRR1, rabi sowing period IRR2 and rabi growth season IRR3. IRRT is an accounting inequality for total use of irrigation and it indicates that irrigation use must be "greater than or equal to" zero. The pumpsets are assumed operated by diesel engines of five horse power.

4.7 Processing Capacity Constraints (Rows 25 to 28)

Different equipments are used in on the farm processing operations. Their capacities are treated as constraints in the production of different crops. Various capacity constraints relate to threshers,

cane crushers, and maize shellers. The excess capacity of threshers upto a certain limit is allowed to be hired out. Rows 25 to 28 represent the capacities of equipment for on the farm processing of crops. THRK and THRR are the threshing capacities for kharif and rabi crops respectively. CCRS indicates cane crushing and MZSL designates maize shelling capacities respectively. These capacities are measured in hours of service available from the respective equipment during the relevant period. Different lengths of the periods are considered depending on the crops the particular equipment is used to process, ie. for how long the harvested crop could be kept unprocessed without incurring losses or for how long the harvesting could be prolonged.

4.8 Capital Inputs Use Equalities (Rows 29 to 32)

Capital inputs are either produced on the farm or purchased. The purchases are either in cash or on credit. To represent alternative input acquisitions, they are divided into two categories, namely, A and B. Both these categories are represented by two constraints for each of the two seasons. Category A inputs are represented by KCIA and RCIA, and include fertiliser and pesticides. These inputs are acquired as kind credit or through cash purchases. They are measured in value terms. The quantities acquired by two means taken together must be exhausted during the respective season. Hence their RHS values are kept at zero. Inputs in category B include the values of seed, fuel, oil and other cash purchased inputs and services and are represented by KCIB and RCIB. Again the acquired quantities are to be fully used within the season.

4.9 Consumption Requirements (Rows 33 to 49)

Consumption requirements are represented by minimum constraints for certain food and fodder items which must be made available either through production on the farm or through purchases. Rows 33 to 49 in Table 1 gives the minimum quantities of foodgrains, gur, feed and fodder and cash for consumption. These requirements are computed on the basis of food and other consumption needs of the family and feed and fodder needs of animals. The cereals, pulses and gur requirements increase with the hiring of labour on the farm.

Only cereals, bhusa and green fodder requirements are forced to be met wholly from farm production. Gur, pulses, kadabi and animal feed are allowed to be met partly or wholly from market purchases. On the other hand, the production of any item excess of its consumption requirements is for sale. These constraints are stated as equality relationships with zero RHS values. Because the total cereal requirements can be met by more than one cereal and they had different prices, their production and disposal is given by separate constraints. They are specified as equality relationships with their RHSs equal to their minimum requirements. Since the production of maize, bajra, rice, wheat, barley, gram and sugarcane is fully disposed of by sale or by transfer to consumption requirements (Sugarcane to gur), the constraints have zero RHS values. Cash consumption needs are fully met from operating cash and consumption credit (purchases) and thus have equality relationship with RHS.

4.10 Liquidity Reserve Requirements (Rows 50 and 51)

Liquidity on a farm is required for current transactions and against financial risks associated with production, marketing and credit activities. The liquidity requirements for transactions are taken care in the cash flows for the purchase of inputs and services while liquidity requirements against risk are to be defined and to be maintained separately. In this example liquidity requirements for two seasons are represented respectively by LRRK and LRRR. These depict the responses of the decision maker against the risks associated with the outcomes of the firm. The RHS elements are computed at certain percentage of the investment in depreciable assets (five per cent in this example). These requirements are further adjusted to get feasible solutions.

4.11 Cash Availability and Use (Rows 52 to 55)

Cash is either available as savings from the previous years, sale proceeds of the current year and [illegible] credit use in the year. Thus cash availability on a farm, in the beginning of the year would be savings from the previous year. This may be supplemented through credit use from different sources. Cash availability in the rabi season would flow from kharif season's income.

While rows 52 and 53 represent cash availability for kharif and rabi seasons, rows 54 and 55 respectively are for its use. Cash available to the firm for kharif came from last year's income a part of which is used and goes to row 54 in the computing process. The balance goes to the liquidity reserve row of LRRK. The value of

reserve is added to the objective function. The cash available for rabi is transferred from kharif income (CINK). It is then allocated between reserve and use during the season. While reserves meet the liquidity requirements and add some value to the objective function, the cash use is transferred to cash use rows. The relationship is "less than or equal to" for kharif cash available and is "equal to" for rabi cash available and cash use for the two seasons. In other words all the transfers must be allocated.

4.12 Operating Cash Equalities (Rows 56 and 57)

These are accounting equalities with zero RHSs which involve cash transferes from cash and credit use to the operating cash and allocate it for cash purchases, hiring labour and other resources, renting land, and meeting consumption needs.

4.13 Credit Availability and Use (Rows 58 to 67)

Credit is available from institutional as well as non-institutional sources. The availability of crop loans depends on the amount of share deposit. The amount available for both the seasons is identical for non-defaulters. A part of the loan is in cash and the other part is in kind. Further, a part of the cash is given only if the kind component is fully utilised. The credit use from this source is represented by two rows for each season. While the used part of credit is transferred to these rows accordingly, the unused credit goes to liquidity reserves. The reserves also add some value to the objective function. The amount transferred to use rows is allocated among kind credit purchases and operating cash for the respective season. The RHS values of credit

use rows thus are zero with equality relationships.

Similarly non-institutional credit availability is computed from farmers responses. For simplicity the amount available for each season is assumed the same. This credit has more degrees of freedom in its use. Again a part of it is used and the other part is saved as liquidity reserve. The used part is transferred to operating cash for allocation.

The institutional credit availability can be increased by purchasing more shares. The maximum availability can go upto Rs.9,000 per member. While the potential activated is added to RHS the share costs are deducted from operating cash in kharif.

4.14 Income Transfer and Cash Reserve Equalities (Rows 68 - 70)

The income generated during two seasons is represented through rows 68 and 69 respectively. Income is generated from sale of crop produce and hiring out of services of some equipment. The kharif income is transferred to cash reserve (row 70), debt payment and rabi cash [illegible] availability. On the other hand a part of rabi income is used for debt payment and the balance goes to the objective function. The total income generated in the two seasons is fully allocated to justify zero RHS values for these rows. The cash reserve equality is developed to maintain reserve from kharif income equal to the cash used during that season. This gives the net availability of kharif income as rabi cash.

4.15 Debt Repayment Equalities (Rows 71 to 74)

These equality constraints are introduced to account for the short term credit use and its repayment from the incomes in the respective seasons. All the debt from different sources and for both the seasons

must be fully paid back to satisfy these equalities.

4.16 Activity Constraints or Bounds (Rows 75 to 93)

Activity constraints are the upper bounds on resource availabilities and the lower bounds on consumption requirements imposed through individual activities. The activity constraints with lower bounds have "greater than or equal to" relationships and those with upper bounds have by "less than or equal to" relationships with their RHSs. The resource constraints imposed through activity bounds include sugarcane ratoon area, consumption credit for two seasons, unactivated credit potential and thresher and tractor hiring out in different periods. Also the consumption of maize, bajra and rice is restricted by upper bounds computed on the basis of food habits prevalent in the study area. The green fodder requirements in for livestock in the two seasons (in acres) are compelled to be met by activity bounds. The investment activities are bounded to specific integer values through minimum or maximum constraints.

5 ACTIVITIES

The list of activities considered in the model and the units in which they are measured are given in Table 2. They include crop production activities; output sale and custom hiring activities; cash and credit purchases, no credit use and debt repayment activities; cash and credit reserve activities; food and feed buying and labour hiring activities; other transfers and investment activities.

Table 2: List of Activities Included in the Models

Col. No.	Description	ID
1	American Cotton - Fallow	ACF
2	American Cotton - Rabi Crop	ACR
3	Desi Cotton - Rabi Crop	DCR
4	Hybrid Maize Manured	HMMN
5	Hybrid Maize Unmanured	HMU
6	Desi Maize	DMZ
7	Desi Maize Shared	DMS
8	Rice	RIC
9	Rice Shared	RIS
10	Groundnut Irrigated	GNI
11	Groundnut Unirrigated	GNU
12	Bajra Irrigated	BJI
13	Bajra Unirrigated	BJU
14	Kharif Pulses	KPL
15	Kharif Fodders	KFD
16	Sugarcane Ratoon	SCR
17	Sugarcane Planted	SCP
18	Wheat after Fallow	WTF
19	Wheat after Kharif Crop	WTK
20	Wheat Shared	WTS
21	Barley Irrigated	BLI
22	Barley Unirrigated	BLU
23	Gram Irrigated	GMI
24	Gram Unirrigated	GMU
25	Mustard	MTD
26	Rabi Pulses	RPL
27	Rabi Fodders	RFD
28	Gur Making	GUR
29	Desi Maize	DMM
30	Bajra	BJM
31	Rice	RIM
32	Wheat	WTM
33	Kharif Pulses	KPM
34	Rabi Pulses	RPM
35	Gur	GRM
36	Kadabi	KDM
37	Bhusa	BSM
38	Hybrid Maize	HMM
39	Barley	BLM
40	Gram	GMM
41	Cane	CNM
42	Thresher in Kharif	THK
43	Thresher in Rabi	THR
44	Tractor Period 1	TR1
45	Tractor Period 2	TR2

Table 2: Cont.....

(1)	(2)		(3)
46	Tractor Total (Hrs.)		TRT
47	Cash Reserve in Kharif (%)	: Zero	KCZR
48		15	KC15
49		30	KC30
50		45	KC45
51		60	KC60
52		75	KC75
53		90	KC90
54		100	KCCT
55	Cash Reserve in Rabi (%)	: Zero	RCZR
56		15	RC15
57		30	RC30
58		45	RC45
59		60	RC60
60		75	RC75
61		90	RC90
62		100	RCCT
63	Inst. Credit Reserve Kharif (%)	: Zero	IKZR
64		17	IK17
65		30	IK30
66		45	IK45
67		60	IK60
68		75	IK75
69		90	IK90
70	Inst. Credit Reserve (%) Rabi	: Zero	IRZR
71		17	IR17
72		30	IR30
73		45	IR45
74		60	IR60
75		75	IR75
76		90	IR90
77	Credit Potential Activation		CPAC
78	Non-Inst. Credit Res. Kharif (%)	: Zero	NKZR
79		15	NK15
80		30	NK30
81		45	NK45
82		60	NK60
83		75	NK75
84		90	NK90
85	Non-Inst. Credit Res. Rabi (%)	: Zero	NRZR
86		15	NR15
87		30	NR30
88		45	NR45
89		60	NR60
90		75	NR75
91		90	NR90
92	Kharif Inputs Cash & Kind		KICK
93	Kharif Inputs Cash only		KICO
94	Rabi Inputs Cash & Kind		RICK

Table 2: Contd....

Col. No.	Description	ID
95	Rabi Inputs Cash Only	KICO
96	Cash Use in Kharif	CSUK
97	Cash Use in Rabi	CSUR
98	Institutional Credit Use in Kharif: A	ICUKA
99	B	ICUKB
100	Institutional Credit Use in Rabi : A	ICURA
101	B	ICURB
102	Non-Institutional Credit Use in Kharif	NCUK
103	Non-Institutional Credit Use in Rabi	NCUR
104	Institutional Kharif Debt Repayment	IDRK
105	Institutional Rabi Debt Repayment	IDRR
106	Non-Institutional Kharif Debt Repayment	NDRK
107	Non-Institutional Kharif Default in Rabi	NDDR
108	Non-Institutional Rabi Debt Repayment	NDRR
109	Pulses Purchase in Kharif	PLPK
110	Pulses Purchase in Rabi	PLPR
111	Feed Purchase in Kharif	FDPK
112	Feed Purchase in Rabi	FDPR
113	Gur Purchase in Kharif and Rabi	GURR
114	Kadabi Purchase in Kharif	KBPR
115	Labour Hiring 1	LBH1
116	Labour Hiring 2	LBH2
117	Labour Hiring 3	LBH3
118	Labour Hiring 4	LBH4
119	Labour Hiring 5	LBH5
120	Labour Hiring 6	LBH6
121	Cane Crusher Hiring	CNCR
122	Maize Sheller Hiring	MZSL
123	Rental Lease of land	LLRL
124	Share Lease of land	LLSR
125	FYM Transfer from Kharif to Rabi	FYMT
126	Maize transfer to Cereal Requirements	MZCR
127	Bajra transfer to Cereal Requirements	BJCR
128	Rice transfer to Cereal Requirements	RCCR
129	Wheat transfer to Cereal Requirements	WTCR
130	Barley transfer to Rabi Feed	BLFR

Table 2: Contd....

Col. No.	Description	ID
131	Gram transfer to Rabi Feed	GMFD
132	Kharif Operating Cash transfer to consumption	KOCC
133	Rabi Operating Cash Transfer to consumption	ROCC
134	Kharif Income transfer to credit purchases	KICC
135	Rabi Income transfer to credit purchases	KIRC
136	Kharif Income to Rabi Cash	RICC
137	Kharif Income to Cash Reserve	KICR
138	Rabi Income to Objective Function	RIOF
139	Tractor Purchase	TRCI
140	Thresher Purchase	THRI
141	Cane Crusher Purchase	CNCS
142	Maize Sheller Purchase	MZSR
143	Pumpset Purchase	PMPS

5.1 Production Activities

Production choices open to farm firms are restricted to the crop varieties commonly grown in the area. All crops are seasonal except sugarcane which is a perennial crop. Cotton and wheat in Cotton-Fallow and Fallow-Wheat rotations, however, reserve land for whole of the year. Sugarcane ratoon and sugarcane planted are considered different production activities. Conversion of cane to 'gur' is treated as an independent production activity. Irrigated and unirrigated crops of bajra, groundnut, barely and gram are represented by separate activities. Local and improved varieties of cotton and wheat are separately represented. Similarly manured and unmanured hybrid maize are treated independent activities. Crops of 'desi' maize, rice, and wheat grown on leased land for which some inputs used and output produced are shared between the cultivator and the landlord are also considered as different set of activities.

5.2 Sale Activities

Crop production activities taken up by the cultivators may be grouped into two categories. One, those crops which are mainly produced for sale, such as cotton, groundnut, and two, those crops which are mainly produced for consumption at home such as wheat, maize, bajra. Similarly, byproducts from the crops may partly be sold. All these sales are represented by different sale activities. Another category of sale activities is the custom hiring out of farm resources such as labour, power and equipment. Surplus services of these resources are sold in the relevant reasons and are represented by independent sale activities.

5.3 Cash and Credit Use, and Reserve Activities

Cash is available to the farmers from cash sale of crop produce and services of farm resources, and credit use from different sources. The former is already discussed under the sale activities. The latter, credit, is available from formal and informal sources. The formal sources are either commercial banks or cooperatives. The use of cooperative credit depends on its activated potential through purchase of shares of cooperative credit institutions. This has been represented by a credit activation activity. Further, as farm production on farms is subjected to various risks, farmers keep liquidity reserves in the form of cash and credit. The choices open to them are different combinations of cash and credit reserves. Different proportions of cash and credit reserves have different values to them as depicted in Figure 1. Since it is difficult to compute as well as use all the values on the non-linear function (infinite) in the model, an arbitrary breakup of whole range is obtained (Table 3).

Table 3: Value of Cash and Credit Reserves at Different Levels on Sample Farms in Central Punjab

Liquidity Reserve	Reservation Price (Rs/Re)			Value of Reserve (Rs/Re)		
	Cash	Inst. Credit	Non-Inst. Credit	Cash	Inst. Credit	Non-Inst. Credit
1.00	1.00	0	0	1.00	0	0
0.90	1.03	0.20	0.30	0.93	0.18	0.27
0.75	1.12	0.35	0.45	0.84	0.26	0.34
0.60	1.25	0.55	0.65	0.75	0.33	0.39
0.45	1.45	0.80	0.90	0.65	0.36	0.41
0.30	1.70	1.10	1.30	0.51	0.33	0.39
0.15[a]	2.00	1.50	1.80	0.30	0.23	0.27

[a] 0.83 for institutional credit

The values attached to each segment of the total range are the adjusted values used by Baker and Bhargava. These adjustments are necessary because of differences in the segmentation of the total range and because Punjab farmers are considered relatively less risk averse than their counterpart in U.P. Each level of cash and credit reserve is considered as an independent activity. Further different sources of credit are represented separately. Since 100 per cent credit reserves have zero value to the firm, these alternatives are not included in the model.

Similarly cash and credit use are independent activities. Two alternatives available to the farmers for acquiring inputs and services are cash and credit purchases. Again cash for purchases is obtained from cash sales or from credit use. In the case of formal credit only a part of it may be used as cash. The other part is kind inputs. All these cash and credit purchases of inputs are represented separately for different sources and for different seasons. The credit purchases of consumption items for two seasons are treated independent activities. All these cash and credit allocation for use is transferred to operating cash for the respective season.

5.4 Debt Repayment Activities

Since all the debt is to be repaid at the end of agricultural year, debt repayment activities are introduced. The debt of each season may be repaid at the end of the season. However, in case of informal credit kharif season dues may be repaid at the end of the rabi season also.

5.5 Purchase Activities

Since not all the household requirements are produced on the farm and since all the services of resources required in the production process are not available on all farms, purchase of food, feed, fodder and services of certain resources becomes inevitable. All these transactions are represented by purchase activities. Various items included in the purchase activities are pulses, gur, feed, fodders, and services of resources such as labour, draft power and equipment.

5.6 Transfer Activities

Some of the activities are introduced to transfer resources from availability to use, reserve, allocation, disposal, etc. These activities are referred to as transfer activities. Some of the examples are transfer of kharif FYM to rabi season; maize, bajra, wheat from production to requirements; barley and gram output to rabi feed requirements; operating cash to consumption cash; consumption credit to its use; incomes to consumption, cash reserve, and objective function.

5.7 Investment Activities

Since some of the farms lack certain desirable investments. Such investments are made available to these farms through investment activities. These activities include investment in tractor, thresher, cane crusher, maize sheller and irrigation pumpset. Formal credit is assumed used. The downpayment if any is paid out of savings from the previous years and hence not included in the model.

6 MATRIX OF COEFFICIENTS

The coefficients are the resource requirements, output and (income) generated from a unit level of an activity. These may be greater than, equal to or less than zero. While the coefficient values greater than zero indicate the use of those resources, less than zero values mean additions to the right hand side, and equal to zero values imply that the particular constraints are not relevant for the activity in reference. Thus with 93 row constraints and 143 activities we have the coefficients matrix of 93 X 143. The objective function values for 143 activities represented by a row vector of 1X143 are also discussed. Thus for our purpose we have developed a modified matrix of 94.X 143 and apportioned it into a number of sub-matrices on the basis of groups of activities. Some of these sub-matrices are zero matrices and hence are not discussed.

6.1 Production Activities

Table 4.1 gives the matrix of coefficients for different crop enterprises. The positive coefficients in the constraint rows for land (owned and leased in), FYM, labour, bullock power, tractor power, irrigation, processing and capital inputs use indicate the per acre requirements of these inputs for individual crop enterprises. The positive entries in the consumption requirement rows indicate the availability of respective item per unit of a particular activity to meet the requirements. It amounts to lowering these requirements by such amounts. The positive coefficients in the liquidity reserve rows utilise liquidity and hence increase its requirements by the same

Table 4.1: Crop Production Activities

Row No.	Col.No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	ID	ACF	ACR	DCR	HMMN	HMU	DMZ	DMS	RIC	RIS	GNI	GNU	BJI	BJU	KPL
1	LNDK	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	LNDR	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4	FLUK	0	0	0	0	0	0	1	0	1	0	0	0	0	0
5	FLUR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	FYMK	0	0	0	10	0	0	0	0	0	0	0	0	0	0
7	FYMR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8a	LAB1	60	60	60	96	96	96	96	120	120	96	84	88	48	70
9a	LAB2	103	103	79	135	135	135	135	48	48	183	136	112	96	93
10a	LAB3	29	19	21	60	60	60	0	0	0	0	0	8	8	0
11a	LAB4	3	0	0	0	0	0	0	0	0	0	0	0	9	0
12a	LAB5	8	11	9	50	50	4	4	42	42	3	3	2	2	3
8b	LAB1	66	66	66	112	112	112	112	219	219	135	116	92	92	84
9b	LAB2	103	103	79	135	135	135	135	48	48	233	210	136	118	93
10b	LAB3	29	29	21	60	60	60	60	0	0	0	0	0	0	0
11b	LAB4	32	0	0	0	0	0	0	0	0	0	0	0	0	0
12b	LAB5	29	93	85	72	32	32	32	64	64	24	64	24	24	24
13	LAB6	192	192	160	0	0	0	0	0	0	0	0	0	0	0
14b	BLK1	8	8	8	12	12	12	12	40	40	32	20	12	12	26
15b	BLK2	4	4	7	4	4	4	4	0	0	0	0	0	0	0
16b	BLK3	19	51	32	40	40	40	40	26	26	24	24	24	24	24
17b	BLKT	73	65	46	56	56	56	56	78	78	70	48	40	40	60
18a	TRC1	2.4	6.0	5.5	9.5	4.5	4.5	4.5	1.5	1.5	1.5	0.8	1.5	0.8	1.5
19a	TRC2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20a	TRCT	7.5	7.5	7.0	11.0	6.0	6.0	6.0	5.0	5.0	3.5	3.0	3.5	3.0	3.5
21	IRR1	13	13	13	19	19	19	19	44	44	13	0	7	0	7
22	IRR2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	IRR3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	IRRT	37	37	37	37	37	37	37	0	0	0	0	0	0	0
25	THRK	0	0	0	0	0	0	0	0	0	0	0	5	4	0
26	THRR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	CNCR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	MZSL	0	0	0	1.5	1.3	1.2	1.2	0	0	0	0	0	0	0
29	KCIA	510	510	333	267	267	200	100	396	198	241	165	330	179	172
30a	KCIB	113	169	153	334	184	184	184	332	332	269	168	102	52	98
30b	KCIB	89	89	85	193	92	92	281	281	241	132	56	16	16	56
31	RCIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32a	RCIB	66	0	0	0	0	0	0	0	0	0	0	0	0	0
32b	RCIB	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Contd.....

Table 4.1: Cont.

Row No.	Col.No. 15	16	17	18	19	20	21	22	23	24	25	26	27	28
	ID	KFD	SCR	SCP	WTF	WTK	WTS	BLI	BLU	GMI	GMU	MST	RPL	RFD	GUR
1	LNDK	1	1	1	1	0	0	0	0	0	0	0	0	0	0
2	LNDR	0	1	1	1	1	1	1	1	1	1	1	1	1	0
4	LLUK	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	LLUR	0	0	0	0	1	0	0	0	0	0	0	0	0	0
6	RYMK	5	0	0	10	0	0	0	0	0	0	0	0	0	0
7	RYMR	0	8	16	0	0	0	0	0	0	0	5	0	10	0
8a	LAB1	40	100	100	40	0	0	0	0	0	0	0	0	0	0
9a	LAB2	220	73	73	2	0	0	2	2	2	2	18	2	88	0
10a	LAB3	0	80	90	13	45	45	12	12	29	29	29	22	340	6
11a	LAB4	0	24	54	121	126	126	63	63	45	45	59	49	365	12
12a	LAB5	2	83	83	106	116	116	88	80	64	60	72	72	105	0
8b	LAB1	40	100	100	72	0	0	0	0	0	0	0	0	0	0
9b	LAB2	220	73	73	16	0	0	16	16	16	16	48	16	122	0
10b	LAB3	0	120	152	40	80	80	26	20	39	28	35	32	240	8
11b	LAB4	0	24	80	121	126	126	63	48	45	30	55	59	365	16
12b	LAB5	16	83	83	106	116	116	88	80	64	60	72	64	105	0
13	LAB6	192	192	160	0	0	0	0	0	0	0	0	0	0	0
14b	BLK1	22	8	32	40	0	0	0	0	0	0	0	0	0	0
15b	BLK2	0	0	32	24	40	40	16	16	22	22	22	16	30	1
16b	BLK3	16	0	0	21	12	12	8	8	16	16	8	10	13	0
17b	BLKT	54	0	0	92	68	68	40	40	54	53	54	42	144	3
18a	TRC1	1.5	0	0	6.5	0	0	0	0	0	0	0	0	0	0
19a	TRC2	0	0	0	1.5	4.0	4.0	1.5	1.5	1.5	1.5	4.0	1.5	0	0.2
20a	TRCT	4.0	0	9.0	12.0	0	0	0	0	0	0	0	0	6.0	0.8
21	IRR1	19	24	24	0	0	0	0	0	0	0	0	0	0	0
22	IRR2	0	18	18	7	7	7	7	0	13	0	13	13	60	0
23	IRR3	0	7	7	30	30	30	18	0	6	3	12	12	60	0
24	IRRT	0	0	0	37	37	37	25	0	19	0	25	25	0	0
25	THRK	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	THRR	0	0	0	10	9	9	6	4	0	0	0	0	0	0
27	CNCR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	MZSL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	KCIA	75	214	214	0	0	0	0	0	0	0	0	0	0	0
30a	KCIB	200	96	96	78	0	0	0	0	0	0	0	0	0	0
30b	KCIB	164	96	96	0	0	0	0	0	0	0	0	0	0	0
31	RCIA	0	335	350	384	384	192	214	174	122	87	275	135	180	0
32a	RCIB	0	248	852	314	204	204	149	95	120	82	180	116	610	8
32b	RCIB	0	248	744	244	142	142	107	53	78	40	108	74	538	5

Table 4.1: Cont.

Row	ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14
34	MZPD	0	0	0	0	0	-1300	-650	0	0	0	0	0	0	0
35	BJPD	0	0	0	0	0	0	0	0	0	-1000	-650	0	0	0
36	RCPD	0	0	0	0	0	0	0	-2850	-1425	0	0	0	0	0
37	WTPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	KPRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	400
39	RPRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	GRRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	KDRQ	0	0	0	26	20	18	9	0	0	14	8	0	0	0
42	BSRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	KFRQ	0	0	0	-160	-150	0	0	0	0	0	0	0	0	0
45	BLPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	GMPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	CNPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50	LRRK	-428	-276	-165	-112	- 89	- 65	- 33	- 182	- 91	- 153	-110	-51	- 36	-56
51	LRRR	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	CINK	-2675	-2300	-1680	0	0	0	0	0	0	-1740	-1125	0	0	-24
69	CINR	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[a] Only for tractor cultivation

[b] Only for bullock cultivation.

Cont.----

Table 4.1: Cont..

Row	ID	15	16	17	18	19	20	21	22	23	24	25	26	27	28
34	MZPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	BJPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	RCPD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	WTPD	0	0	0	-1800	-1600	-800	0	0	0	0	0	0	0	0
38	KPRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	RPRQ	0	0	0	0	0	0	0	0	0	0	400	0	0	0
40	GRRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	100
41	KDRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	BSRQ	0	0	0	26	24	12	14	8	0	0	0	0	0	0
43	KFRQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	BLPD	0	0	0	0	0	0	-120	-70	0	0	0	0	0	0
46	GMPD	0	0	0	0	0	0	0	0	-50	-35	0	0	0	0
47	CNPD	0	-280	-300	0	0	0	0	0	0	0	0	0	0	12
50	LRRK	42	120	150	0	0	0	0	0	0	0	0	0	0	0
51	LRRR	0	230	300	141	108	54	86	63	68	58	225	43	54	0
68	CINK	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	CINR	0	0	0	0	0	0	0	0	-40	-24	-1520	-24	0	0

amount. The larger these figures the higher is the risk associated with the production of such crops. The negative coefficients in the income rows and production and disposal rows indicate the additions to income and inventory of respective produce. The income is generated from the sale of crop produce not consumed at home.

6.2 Sale Activities

Table 4.2 gives the matrix of coefficients for crop produce sale activities. The negative unit figures in the output requirements rows mean increase in the requirements as a unit quantity is taken away for sale. On the other hand positive unit figures in the production and disposal rows indicate reduction in the inventory of those produce. The earnings are added to the income as indicated by negative coefficients in the income rows.

6.3 Custom Hiring Out Activities

Table 4.3 gives the coefficients matrix for custom hiring out of surplus services of the farm resources. The custom hiring adds to the income as indicated by negative coefficients in the income rows. The positive coefficients in the availability rows indicate hiring out a unit of respective resource. The operating cash used in the form of fuel, etc., is indicated by positive coefficients in the respective operating cash use rows.

Table 4.3: Custom Hiring Out Activities

Row No.	Col No.	42	43	44	45	46
	ID	THK	THR	TR1[a]	TR2[a]	TR3[a]
18	TRC1	0	0	1	0	0
19	TRC2	0	0	0	1	0
20	TRCT	0	0	1	1	1
25	THRK	1	0	0	0	0
26	THRR	0	1	0	0	0
56	OCSK	2	0	12	0	6
57	OCSR	0	2	0	12	6
68	CINK	-5	0	-25	0	-12.5
69	CINR	0	-5	0	-25	-12.5

6.4 Cash and Credit Reserve Activities

Table 4.4 and 4.5, respectively give the matrices of coefficients for cash and credit reserve activities in the model. Columns 47 to 62 are cash reserve activities, 63 to 77 institutional credit reserve and 78 to 91 non-institutional-credit reserve activities. The unit positive elements in availability rows indicate that one rupee is taken for allocation between the reserve and the use in the ratio given by negative figures in the use rows and positive figures in the liquidity reserve rows. As conceptualised, the reserves have some values to the cultivators which is shown by positive elements in the objective function for individual reserve activities. The activation of unutilised institutional credit potential for use is represented by the coefficient of .125 in the kharif operating cash which makes available one rupee of credit for each of the two seasons as given by negative unit values in the credit availability rows.

Table 4.2: Crop Produce Sale Activities

Row No.	Col. No. / ID	29 DMM	30 BJM	31 RIM	32 WTM	33 KPM	34 RPM	35 GRM	36 KDM	37 BSM	38 HMM	39 BLM	40 GMM	41 CNM
34	MZPD	1	0	0	0	0	0	0	0	0	0	0	0	0
35	BJPD	0	1	0	0	0	0	0	0	0	0	0	0	0
36	RCPD	0	0	1	0	0	0	0	0	0	0	0	0	0
37	WTPD	0	0	0	1	0	0	0	0	0	0	0	0	0
38	KPRQ	0	0	0	0	-1	0	0	0	0	0	0	0	0
39	RPRQ	0	0	0	0	0	-1	0	0	0	0	0	0	0
40	GRRQ	0	0	0	0	0	0	-1	0	0	0	0	0	0
41	KDRQ	0	0	0	0	0	0	0	-1	0	0	0	0	0
42	BSRQ	0	0	0	0	0	0	0	0	-1	0	0	0	0
43	KFRQ	0	0	0	0	0	0	0	0	0	-1	0	0	0
45	BLPD	0	0	0	0	0	0	0	0	0	0	1	0	0
46	GMPD	0	0	0	0	0	0	0	0	0	0	0	1	0
47	CNPD	0	0	0	0	0	0	0	0	0	0	0	0	1
56	OCSK	0	0	0	0	0	0	0	0	0	0	0	0	0
57	OCSR	0	0	0	0	0	0	0	0	0	0	0	0	0
68	CINK	-1	-.85	-.80	0	-2	0	0	-.40	0	-10	0	0	0
69	CINR	0	0	0	-1.125	0	-1.3	-1.4	0	-1	0	-9.0	-15	-12.5

Table 4.4: Cash Reserve Activities

Col. No.	Row No. ID	50 LRRK	51 LRRR	52 CSAK	53 CSAR	54 CSUK	55 CSUR	Z
47	KCZR	0	0	1	0	-1	0	0
48	KC15	-.15	0	1	0	-.85	0	.30
49	KC30	-.30	0	1	0	-.70	0	.51
50	KC45	-.45	0	1	0	-.55	0	.65
51	KC60	-.60	0	1	0	-.40	0	.75
52	KC75	-.75	0	1	0	-.25	0	.84
53	KC90	-.90	0	1	0	-.10	0	.94
54	KCCT	- 1	0	1	0	0	0	1
55	RCZR	0	0	0	1	0	-1	0
56	RC15	0	-.15	0	1	0	-.85	.30
57	RC30	0	-.30	0	1	0	-.70	.51
58	RC45	0	-.45	0	1	0	-.55	.65
59	RC60	0	-.60	0	1	0	-.40	.75
60	RC75	0	-.75	0	1	0	-.25	.84
61	RC90	0	-.90	0	1	0	-.10	.94
62	RCCT	0	- 1.	0	1	0	0	1

Table 4.5: Credit Reserve Activities

Col. No.	Row No.	50	51	56	58	59	60	61	62	63	64	65	66	67	Z
	ID	LRRK	LRRR	OCSK	ICAK	ICAR	ICUKA	ICUKB	ICURA	ICURB	NCAK	NCAR	NCUK	NCUR	
63	IKZR	0	0	0	1	0	-1	-1	0	0	0	0	0	0	0
64	IK17	-.17	0	0	1	0	-.83	0	0	0	0	0	0	0	.25
65	IK30	-.30	0	0	1	0	-.70	0	0	0	0	0	0	0	.33
66	IK45	-.45	0	0	1	0	-.55	0	0	0	0	0	0	0	.36
67	IK60	-.60	0	0	1	0	-.40	0	0	0	0	0	0	0	.33
68	IK75	-.75	0	0	1	0	-.25	0	0	0	0	0	0	0	.26
69	IK90	-.90	0	0	1	0	-.10	0	0	0	0	0	0	0	.18
70	IRZR	0	0	0	0	1	0	0	-1	-1	0	0	0	0	0
71	IR17	0	-.17	0	0	1	0	0	-.83	0	0	0	0	0	.25
72	IR30	0	-.30	0	0	1	0	0	-.70	0	0	0	0	0	.33
73	IR45	0	-.45	0	0	1	0	0	-.55	0	0	0	0	0	.36
74	IR60	0	-.60	0	0	1	0	0	-.40	0	0	0	0	0	.33
75	IR75	0	-.75	0	0	1	0	0	-.25	0	0	0	0	0	.26
76	IR90	0	-.90	0	0	1	0	0	-.10	0	0	0	0	0	.18
77	CPAC	0	0	.125	-1	-1	0	0	0	0	0	0	0	0	0
78	NKZR	0	0	0	0	0	0	0	0	0	1	0	-1	0	0
79	NK15	-.15	0	0	0	0	0	0	0	0	1	0	-.85	0	.27
80	NK30	-.30	0	0	0	0	0	0	0	0	1	0	-.70	0	.39
81	NK45	-.45	0	0	0	0	0	0	0	0	1	0	-.55	0	.41
82	NK60	-.60	0	0	0	0	0	0	0	0	1	0	-.40	0	.39
83	NK75	-.75	0	0	0	0	0	0	0	0	1	0	-.25	0	.34
84	NK90	-.90	0	0	0	0	0	0	0	0	1	0	-.10	0	.27
85	NRZR	0	0	0	0	0	0	0	0	0	0	1	0	-1	0
86	NR15	0	-.15	0	0	0	0	0	0	0	0	1	0	-.85	.27
87	NR30	0	-.30	0	0	0	0	0	0	0	0	1	0	-.70	.39
88	NR45	0	-.45	0	0	0	0	0	0	0	0	1	0	-.55	.41
89	NR60	0	-.60	0	0	0	0	0	0	0	0	1	0	-.40	.39
90	NR75	0	-.75	0	0	0	0	0	0	0	0	1	0	-.25	.34
91	NR90	0	-.90	0	0	0	0	0	0	0	0	1	0	-.10	.27

6.5 Cash Allocation Activities

Tables 4.6 gives the matrix of coefficients for the cash allocation activities. These are mainly the transfer activities. The positive unit coefficients in the cash use rows indicated that a rupee of available cash is transfered to operating cash rows as shown by negative unit elements. On the other hand positive unit coefficients in operating cash rows show that one rupee of available operating cash is taken away for allocation to capital inputs as shown by negative coefficients in these rows. This cash is available for purchase of capital inputs of category A and B in the respective seasons.

Table 4.6: Cash Allocation Activities

Row No.	Col. No.	92	93	94	95	96	97
	ID	KICK	KICO	RICK	RICO	CSUK	CSUR
29	KCIA	-1	0	0	0	0	0
30	KCIB	0	-1	0	0	0	0
31	RCIA	0	0	-1	0	0	0
32	RCIB	0	0	0	-1	0	0
54	CSUK	0	0	0	0	1	0
55	CSUR	0	0	0	0	0	1
56	OCSK	1	1	0	0	-1	0
57	OCSR	0	0	1	1	0	-1

6.6 Credit Allocation and Debt Repayment Activities

The coefficients for credit allocation and debt repayment activities are given in Table 4.7. Just like cash allocation credit allocation and debt repayment are the transfer activities. Credit funds are transfered from use rows to operating cash and capital inputs acquired as kind

Table 4.7: Credit Allocation and Debt Repayment Activities

Row No.	Col. No. 98	99	100	101	102	103	104	105	106	107	108
	ID	ICKA	ICKB	ICRA	ICRB	NCUK	NCUR	IDRK	IDRR	NDRK	NDDK	NDRR
29	KCIA	-.8	-.67	0	0	0	0	0	0	0	0	0
31	RCIA	0	0	-.8	-.67	0	0	0	0	0	0	0
56	OCSK	-.2	-.33	0	0	-1	0	0	0	0	0	0
57	OCSR	0	0	-.2	-.33	0	-1	0	0	0	0	0
60	ICUKA	1	1	0	0	0	0	0	0	0	0	0
61	ICUKB	0	1	0	0	0	0	0	0	0	0	0
62	ICURA	0	0	1	1	0	0	0	0	0	0	0
63	ICURB	0	0	0	1	0	0	0	0	0	0	0
66	NCUK	0	0	0	0	1	0	0	0	0	0	0
67	NCUR	0	0	0	0	0	1	0	0	0	0	0
68	CINK	0	0	0	0	0	0	1.06	0	1.09	0	0
69	CINR	0	0	0	0	0	0	0	1.06	1.00	1.18	1.09
71	IDRK	-1	-1	0	0	0	0	1	0	0	0	0
72	IDRK	0	0	-1	-1	0	0	0	1	0	0	0
73	NDRK	0	0	0	0	-1	0	0	0	1	1	0
74	NDRR	0	0	0	0	0	-1	0	0	0	0	1

credit in the ration given by negative coefficients in these rows. The negative unit elements in the debt rows are the additions to credit use for accounting purposes (zero in the beginning). The positive unit values in the debt repayment rows for different agencies indicate the debt neutrilisation. The actual payment of principal and interest is, however, made from the income as indicated by positive values in the income rows of the respective season.

6.7 Food and Feed Buying Activities

Table 4.8 gives the coefficients for purchase activities for pulses, gur, feed and kadabi.

Table 4.8: Food and Feed Purchase Activities

Row No.	Col. No.	109	110	111	112	113	114
	ID	PLPK	PLPR	FDPK	FDPR	GURP	KBPK
38	KPRQ	1	0	0	0	0	0
39	RPRQ	0	1	0	0	0	0
40	GRRQ	0	0	0	0	1	0
41	KDRQ	0	0	0	0	0	0
43	KFRQ	0	0	1	0	0	1
44	RFRQ	0	0	0	1	0	0
56	OSCK	2.5	0	1.4	0	.9	.05
57	OSCR	0	2.25	0	1.4	.9	0

Positive coefficients in the requirement rows indicate their fulfilment while in the operating cash rows the positive elements are the prices paid per unit of the item. Similarly, in Table 4.9 positive entries in the operating cash rows for labour hiring, equipment hiring, and land leasing activities indicate wage rate, custom rates and land rent

respectively. As labour is provided food, its hiring in increases the food requirements of cereals, pulses and gur as indicated by negative elements in their requirement rows. The negative unit values in the availability rows for these resources indicate additions to the respective resource hired in.

6.8 Transfer Activities

The coefficients for transfer activities indicate transfer of resources and produce from one row to another as depicted in Table 4.10. The positive unit elements in production and disposal rows for maize, bajra, rice, wheat, barley and gram indicate that these commodities are transfered to cereals and feed requirements as indicated by negative elements in their requirement rows. Similarly, positive unit elements in the availability rows of kharif FYM, operating cash and consumption credit (purchases) for two seasons indicated their transfer respectively to the rabi FYM availability, consumption cash, and consumption credit needs as indicated by the negative unit elements in these rows. The unit positive coefficients in the income rows represent the allocation of income to consumption, cash reserve, rabi cash availability and objective function as shown by negative entries in the respective rows. The kharif income goes to rabi cash availability, cash reserve and objective function while rabi income goes to the objective function directly.

6.9 Investment Activities

Table 3.11 also gives the coefficients for the investment activities considered in the model. These activities add to the availability of

Table 4.9: Hiring and Renting in Activities

Row No.	Col. No.	115	116	117	118	119	120	121	122	123	124
	ID	LBH1	LBH2	LBH3	LBH4	LBH5	LBH6	CNCH	MZSH	LLRL	LLSR
1	LNDK	0	0	0	0	0	0	0	0	-1	-1
2	LNDR	0	0	0	0	0	0	0	0	-1	-1
3	LLTX	0	0	0	0	0	0	0	0	1	1
4	SLUK	0	0	0	0	0	0	0	0	0	-1
5	SLUR	0	0	0	0	0	0	0	0	0	-1
8	LAB1	-1	0	0	0	0	0	0	0	0	0
9	LAB2	0	-1	0	0	0	0	0	0	0	0
10	LAB3	0	0	-1	0	0	0	0	0	0	0
11	LAB4	0	0	0	-1	0	0	0	0	0	0
12	LAB5	0	0	0	0	-1	0	0	0	0	0
13	LAB6	0	0	0	0	0	-1	0	0	0	0
27	CCRS	0	0	0	0	0	0	-1	0	0	0
28	MZS1	0	0	0	0	0	0	0	-1	0	0
33	TCRQ	-.060	-.060	-.060	-.060	-.060	-.060	0	0	0	0
38	KPRQ	-.003	-.003	0	0	0	-.003	0	0	0	0
39	RPRQ	0	0	-.003	-.003	-.003	0	0	0	0	0
40	GNRQ	-.0125	-.0125	-.0125	-.0125	-.0125	-.0125	0	0	0	0
56	OCSK	1	1	0	0	0	1	0	5	500	0
57	OCSR	0	0	1	1	2	0	5	0	0	0

Table 4.10: Transfers Activities

Row No.	Col.No.	125	126	127	128	129	130	131	132	133	134	135	136	137	138
	ID	FYMT	MZCR	BJCR	RCCR	WTCR	BLFR	CMFR	KOCC	ROCC	KICC	RICC	KIRC	RICR	RIOF
6	FYMK	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	FYMR	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
33	TCRQ	0	-1	-1	-1	-1	0	0	0	0	0	0	0	0	0
34	MZPD	0	1	0	0	0	0	0	0	0	0	0	0	0	0
35	BJPD	0	0	1	0	0	0	0	0	0	0	0	0	0	0
36	RCPD	0	0	0	1	0	0	0	0	0	0	0	0	0	0
37	WTPD	0	0	0	0	1	0	0	0	0	0	0	0	0	0
44	RFRQ	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0
45	BLPD	0	0	0	0	0	1	0	0	0	0	0	0	0	0
46	GMPD	0	0	0	0	0	0	1	0	0	0	0	0	0	0
48	CCNK	0	0	0	0	0	0	0	1	0	1	0	0	0	0
49	CCNR	0	0	0	0	0	0	0	0	1	0	1	0	0	0
53	CSAR	0	0	0	0	0	0	0	0	0	0	0	-1	0	0
56	OCSK	0	0	0	0	0	0	0	1	0	0	0	0	0	0
57	OCSR	0	0	0	0	0	0	0	0	1	0	0	0	0	0
68	CINK	0	0	0	0	0	0	0	0	0	1.01	0	1	1	0
69	CINR	0	0	0	0	0	0	0	0	0	0	1.01	0	0	1
70	CRSV	0	0	0	0	0	0	0	0	0	0	0	0	-1	0
	Z	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1

services of respective items, as shown by the negative elements in the respective rows. They utilize investment credit. The repayment instalments as indicated by positive figures are paid from the income in two seasons.

Table 4.11: Investment Activities

Row No.	Col. No.	139	140	141	142	143
	ID	TRCI	PMPS	THRI	CNCS	MZSR
18	TRC1	-240	0	0	0	0
19	TRC2	-240	0	0	0	0
20	TRC3	-1000	0	0	0	0
21	IRR1	0	-240	0	0	0
22	IRR2	0	-240	0	0	0
23	IRR3	0	-360	0	0	0
25	THRK	0	0	-160	0	0
26	THRR	0	0	-240	0	0
27	CCRS	0	0	0	-480	0
28	MZSL	0	0	0	0	-160
68	CINK	4370	687	413	413	275
69	CINR	4370	687	413	413	275

7 COMPUTING STRATEGIES FOR ALTERNATIVE SITUATIONS

We have presented a general model to be used for various situation with certain modifications in the constraints and activities. The RHS values for the constraints are given for bullock and tractor operated large farms. These may be replaced by the resource availabilities and consumption requirements for any other farms situation eg. small bullock operated, medium bullock operated or medium tractor operated farms. The constraints and activities not relevant for a particular situation can be dropped. For instance, in case of bullock operated farms, tractor

availability constraints are not relevant. Similarly labour and input constraints relevant for bullock farms need to be included. To start with the resource availabilities in the last year may be considered effective. This strategy would indicate the possibilities of increasing the value of the objective function by mere changes in the input levels and cropping patterns. In an other strategy labour hiring could be unbounded to reflect the possibility of improving the utilisation of farm resources through higher labour use. In still another strategy institutional credit availability may be increased to the permissible maximum credit limit. This would increase the net cash flows through better use of surplus resources. Finally some investment activities may be introduced to examine the profitability of having these investments vs hiring their services or even no use of them.

Figure 1: Reservation Price of Cash and Credit Reserves (Rs./Re.)