FARM PLANNING - Ranjith Ramaswamy

				HEIFER REARED	DAIRY COWS									
AGE	0				1	2	3	4	5	6	7	8	9	10
	BULLOCKS	TOTAL HEIFER	HEIFER SOLD	HEIFER REARED										
CURRENT YEAR				10	10	10	10	10	10	10	10	10	10	10
YEAR 1	53.735	53.735	30.935	22.8	9.5	9.5	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
YEAR 2	52.34185	52.34185	40.757423	11.584427	21.66	9.025	9.31	9.604	9.604	9.604	9.604	9.604	9.604	9.604
YEAR 3	57.435807	57.435807	57.435807	0	11.00520565	20.577	8.8445	9.1238	9.41192	9.41192	9.41192	9.41192	9.41192	9.41192
YEAR 4	56.96428593	56.964286	56.964286	0	0	10.45494537	20.16546	8.66761	8.941324	9.2236816	9.2236816	9.2236816	9.2236816	9.2236816
YEAR 5	50.85343583	50.853436	50.853436	0	0	0	10.24584646	19.7621508	8.4942578	8.76249752	9.03920797	9.03920797	9.03920797	9.039207968

PERCENTAGE OF SURVIVAL FOR HEIFERS AND DAIRY COWS												
AGE	0	1	2	3	4	5	6	7	8	9	10	11	12
YEAR 1	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
YEAR 2	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
YEAR 3	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
YEAR 4	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
YEAR 5	0.95	0.95	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

CALCULATION OF NO OF CALVES IN EVERY YEAR

	NO OF COWS IN A YEAR	NO OF CALVES PER COW	TOTAL CALVES	PROBABILITY OF BULLOCKS WHICH WERE CALVES	NO OF BULLOCKS WHICH WERE CALVES	PROBABILITY OF HEIFER WHICH WERE CALVES	NO OF HEIFER WHICH WERE CALVES	CONSTRAINT	TOTAL HEIFERS WHICH WERE SOLD AND REARED
YEAR 1	97.7	1.1	107.47	0.5	53.735	0.5	53.735	=	53.735
YEAR 2	95.167	1.1	104.6837	0.5	52.34185	0.5	52.34185	=	52.34185
YEAR 3	104.42874	1.1	114.871614	0.5	57.435807	0.5	57.435807	=	= 57.435807
YEAR 4	103.571429	1.1	113.9285719	0.5	56.96428593	0.5	56.96428593	=	56.964286
YEAR 5	92.46079242	1.1	101.7068717	0.5	50.85343583	0.5	50.85343583	=	50.853436

PROFIT ON SELLING CALVES

	NO OF BULLOCKS SOLD	NO OF HEIFER SOLD	PROFIT PER BULLOCKS
YEAR 1	53.735	30.935	30
YEAR 2	52.34185	40.757423	30
YEAR 3	57.435807	57.435807	30
YEAR 4	56.9642859	56.964286	30
YEAR 5	50.8534358	50.853436	30

TOTAL PROFIT ON SELLING C

GRAIN CONSUMPTION

GRAIN GROWN IN ACRES

	GROUP				
YEAR	GROUP 1	GROUP 2	GROUP 3	GROUP 4	TOTAL
YEAR 1	20	0	0	0	20
YEAR 2	20	0	0	0	20
YEAR 3	20	3.1351795	0	0	23.1351795
YEAR 4	20	0	0	0	20

CULTIVATION PER ACRE IN TONS

GROUP			
GROUP 1	GROUP 2	GROUP 3	GROUP 4
1.1	0.9	0.8	0.65

GRAIN GROWN IN TONS

YEAR	GROUP 1	GROUP 2
YEAR 1	22	0
YEAR 2	22	0
YEAR 3	22	2.82166155
YEAR 4	22	0

YEAR 5	20	0	0	0	20
	<=	<=	<=	<=	
	≤ 20	≤ 30	≤ 20	≤ 10	

YEAR 5	22	0

YEARS	NO OF DAIRY COWS IN EACH YEAR	NO OF GRAIN NEED FOR A COW IN TON	NO OF GRAIN IN TONS NEED IN A YEAR		GRAIN GROWN OR BOUGHT	GRAIN BOUGHT	GRAIN GROWN USED TO FEED COW	GRAIN SOLD	PROFIT PER TON ON SELLING GRAIN	PROFIT OF SELLING GRAINS IN A YEAR	COST TO BUY GRAIN PER TON	COST TO BUY GRAIN IN A YEAR	SUM OF GRAIN GROWN USED FOR COW AND GRAIN SOLD	CONSTRAINT
YEAR 1	97.7	0.6	58.62	<=	58.62	36.62	22	0	75	0	90	3295.8	22	=
YEAR 2	95.167	0.6	57.1002	<=	57.1002	35.1002	22	0	75	0	90	3159.018	22	=
YEAR 3	104.42874	0.6	62.657244	<=	≤ 62.657244	37.835582	24.821662	0	75	0	90	3405.20238	24.821662	=
YEAR 4	103.571429	0.6	62.14285738	<=	62.142857	40.142857	22	0	75	0	90	3612.85713	22	=
YEAR 5	92.46079242	0.6	55.47647545	<=	55.476475	33.476475	22	0	75	0	90	3012.88275	22	=
									TOTAL PROFIT IN SELLING GRAIN	0	TOTAL COST IN BUYING GRAIN	16485.7603		

SUGAR BEET CONSUMPTION

	NO OF COWS IN EACH YEAR	SUGAR BEET NEED PER COW IN TON	SUGAR BEET NEEDED IN A YEAR	CONSTRAINT	SUGAR BEET BOUGHT AND PRODUCED	SUGAR BEET BROUGHT	SUGAR BEET GROWN	SUGAR BEET SOLD	PROFIT PER TON ON SELLING SUGAR BEET	PROFIT ON SELLIGN SUGAR BEET IN A YEAR	COST TO BUY SUGAR BEET PER TON	COST TO BUY SUGAR BEET IN A YEAR	SUGAR BEET GROWN USED FOR COW AND SUGAR BEET SOLD	CONSTRAINT
YEAR 1	97.7	0.7	68.39	<=	68.39	0	68.39	22.76323	58	1320.26734	70	0	91.15323	=
YEAR 2	95.167	0.7	66.6169	<=	66.6169	0	66.6169	27.391498	58	1588.70688	70	0	94.008398	=
YEAR 3	104.42874	0.7	73.100118	<=	≤ 73.100118	0	73.100118	24.549898	58	1423.89408	70	0	97.650016	=
YEAR 4	103.571429	0.7	72.50000028	<=	72.5	0	72.5	42.142857	58	2444.28571	70	0	114.642857	=
YEAR 5	92.46079242	0.7	64.72255469	<=	64.722554	0	64.722554	66.586258	58	3862.00296	70	0	131.308812	=

ACREAGE

	NO OF HEIFERS IN A YEAR	PERCENTAGE OF ACRE NEEDED FOR HEIFER	NO OF ACRE NEEDED FOR HEIFERS IN A YEAR	NO OF ACRE NEED FOR COWS IN A YEAR	NO OF ACRE USED TO GROW GRAIN IN A YEAR	NO OF ACRE USED TO GROW SUGAR BEET IN A YEAR	TOTAL ACRE USED	CONSTRAINT	
YEAR 1	32.3	0.6666	21.53118	97.7	20	60.76882	200	<=	200

No of acres used by Heifer

HA_j =0.66 HR_j+0.66H_{1j} For j = 1 to 5

Acreage Constraint

HA_j+C_j+GA_j+SBA_j <= 200 For j = 1 to 5

YEAR 2	33.244427	0.6666	22.16073504	95.167	20	62.672265	200	<=		200
YEAR 3	11.00520565	0.6666	7.336070086	104.42874	23.1351795	65.100011	200.0000006	<=	≤	200
YEAR 4	0	0.6666	0	103.571429	20	76.428571	200	<=		200
YEAR 5	0	0.6666	0	92.46079242	20	87.539208	200.0000004	<=		200

ACCOMMODATION

YEAR	NO OF COWS	CONSTRAINT	TOTAL CAPACITY	INITIAL CAPACITY	ADDITIONAL CAPACITY	COST PER ADDITIONAL CAPACITY	COST FOR ADDITIONAL CAPACITY	CAPITAL OUTLAY YEARLY COST	(4+year)
YEAR 1	130	<=	130	130	0	39.71	0	0	5
YEAR 2	128.411427	<=	130	130	0	39.71	0	0	6
YEAR 3	115.4339457	<= ≤	130	130	0	39.71	0	0	7
YEAR 4	103.571429	<=	130	130	0	39.71	0	0	8
YEAR 5	92.46079242	<=	130	130	0	39.71	0	0	9
							Total outlay cost	0	

Accommodation constraint

$HR_j+C_j+H1_j+C_j$ <= 130 + ADC_j For j = 1 to 5

Additional Accommodation cost

$ADCC_j$ = 39.71 $\sum_{k=1}^{j} ADC_j$ For j = 1 to 5

LABOUR

	NO OF HEIFERS	NO OF COWS	NO OF ACRES USED FOR GRAIN	NO OF ACRES USED FOR SUGAR BEET
YEAR 1	32.3	97.7	20	60.76882
YEAR 2	33.244427	95.167	20	62.672265
YEAR 3	11.00520565	104.42874	23.1351795	65.100011
YEAR 4	0	103.571429	20	76.428571
YEAR 5	0	92.46079242	20	87.539208

	LABOUR IN HOURS PER UNIT	LABOUR NEEDED FOR HEIFERS IN A YEAR	LABOUR NEEDED FOR COWS IN A YEAR	LABOUR NEEDED TO GROW GRAIN IN A YEAR	LABOUR NEEDED TO GROW SUGAR BEET IN A YEAR	TOTAL		TOTAL LABOUR AVAILABLE	INITIAL CAPACITY OF LABOUR
		10	42	4	14				
YEAR 1	**YEAR 1**	323	4103.4	80	850.76348	5357.16348	<=	5500	5500
YEAR 2	**YEAR 2**	332.44427	3997.014	80	877.41171	5286.86998	<=	5500	5500
YEAR 3	**YEAR 3**	110.0520565	4386.00708	92.540718	911.400154	5500.00001	<= ≤	5500	5500
YEAR 4	**YEAR 4**	0	4350.000017	80	1069.99999	5500.00001	<=	5500	5500
YEAR 5	**YEAR 5**	0	3883.353282	80	1225.54891	5188.90219	<=	5500	5500

OTHER COST

	HEIFER	COW	GRAIN COST	SUGAR BEET COST	TOTAL COST
COST PER UNIT	50	100	15	10	
YEAR 1	1615	9770	300	607.6882	12292.6882
YEAR 2	1662.22135	9516.7	300	626.72265	12105.644
YEAR 3	550.2602825	10442.874	347.0276925	651.00011	11991.16209
YEAR 4	0	10357.1429	300	764.28571	11421.42861
YEAR 5	0	9246.079242	300	875.39208	10421.47132
				TOTAL OTHER COST	58232.39421

Other cost
OTC_j = $100C_j$+$50HR_j$+$50H_{1j}$+$50GA_j$ +$10SBA_j$
For j = 1 to 5

Profit on selling Milk from Dairy cows
PM_j = $370C_j$ For j = 1 to 5

PROFIT FROM MILK

YEAR	NO OF COWS IN A YEAR	PROFIT PER COW	TOTAL PROFIT FROM MILK IN A YEAR
YEAR 1	97.7	370	36149
YEAR 2	95.167	370	35211.79
YEAR 3	104.42874	370	38638.6338
YEAR 4	103.571429	370	38321.42872
YEAR 5	92.46079242	370	34210.4932

PROFIT FROM SELLING 12 YEAR OLD DAIRY COWS

YEAR	NO OF COWS IN 12 YEARS OLD	PROFIT PER COW ON SELLING OLD COWS	TOTAL PROFIT ON SELLING DAIRY COWS IN A YEAR
YEAR 1	9.8	120	1176
YEAR 2	9.604	120	1152.48
YEAR 3	9.41192	120	1129.4304
YEAR 4	9.2236816	120	1106.841792
YEAR 5	9.039207968	120	1084.704956

REVENUE

	REVENUE FROM SELLING HEIFERS	REVENUE FROM SELLING BULLOCKS	REVENUE FROM SELLING OLD COWS	REVENUE FROM SELLING MILK	REVENUE FROM SELLING GRAIN	REVENUE FROM SELLING SUGAR BEET	TOTAL REVENUE IN A YEAR
YEAR 1	1237.4	1612.05	1176	36149	0	1320.26734	41494.71734
YEAR 2	1630.29692	1570.2555	1152.48	35211.79	0	1588.706884	41153.5293
YEAR 3	2297.43228	1723.07421	1129.4304	38638.6338	0	1423.894084	45212.46477
YEAR 4	2278.57144	1708.928578	1106.841792	38321.42872	0	2444.285706	45860.05623
YEAR 5	2034.13744	1525.603075	1084.704956	34210.4932	0	3862.002964	42716.94163

$Revenue_j$ = PM_j+PB_j+PH_j+$120H_{12j}$ +$GTSP_j$+$SBTSP_j$ For j = 1 to 5

EXPENDITURE

	BUYING GRAIN	BUYING SUGAR BEET	LABOUR COST	OTHER COST	CAPITAL OUTLAY COST	TOTAL EXPENDITURE
YEAR 1	3295.8	0	4000	12292.6882	0	19588.4882

Expenditure
$Expenditure_j$ = $GTBC_j$+$SBTBC_j$+$ADLC_j$+$ADCC_j$ +OTC_j+4000.
For j = 1 to 5

YEAR 2	3159.018	0	4000	12105.644	0	19264.662
YEAR 3	3405.20238	0	4000	11991.16209	0	19396.36447
YEAR 4	3612.85713	0	4000	11421.42861	0	19034.28574
YEAR 5	3012.88275	0	4000	10421.47132	0	17434.35407

PROFIT

	REVENUE	EXPENDITURE	PROFIT			
YEAR 1	41494.71734	19588.4882	21906.22914	>=	≥	0
YEAR 2	41153.5293	19264.662	21888.8673	>=		0
YEAR 3	45212.46477	19396.36447	25816.10031	>=		0
YEAR 4	45860.05623	19034.28574	26825.7705	>=		0
YEAR 5	42716.94163	17434.35407	25282.58756	>=		0
		TOTAL PROFIT	121719.5548			

max

NO OF DAIRY COWS AT THE END OF 5 YEARS

50 <= ≤92.4607924 <= ≤ 175

Objective Function

Maximize : $\sum_{j=1}^{5} Profit_j - 39.71 \sum_{j=1}^{5} (4+j) ADC_j$

Profit

$Profit_j = Revenue_j - Expenditure_j$

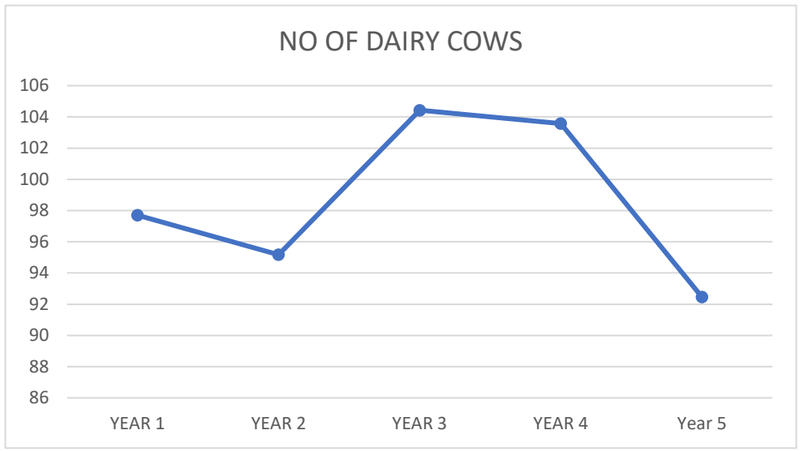
For j = 1 to 5

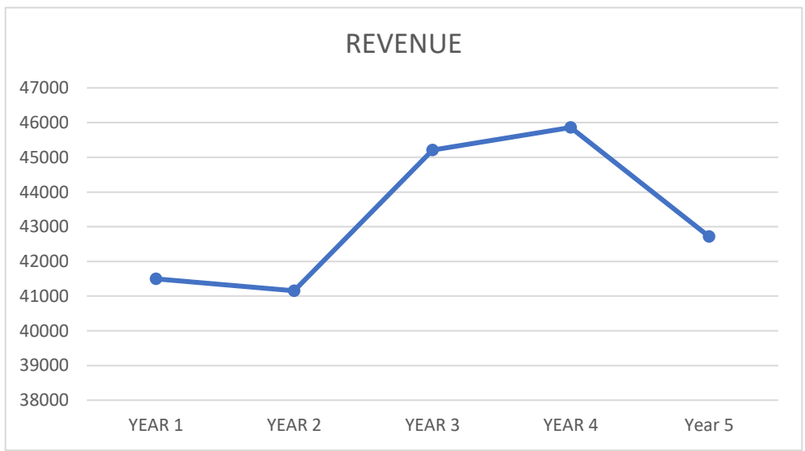
Profit Condition

Year 1

Year 2

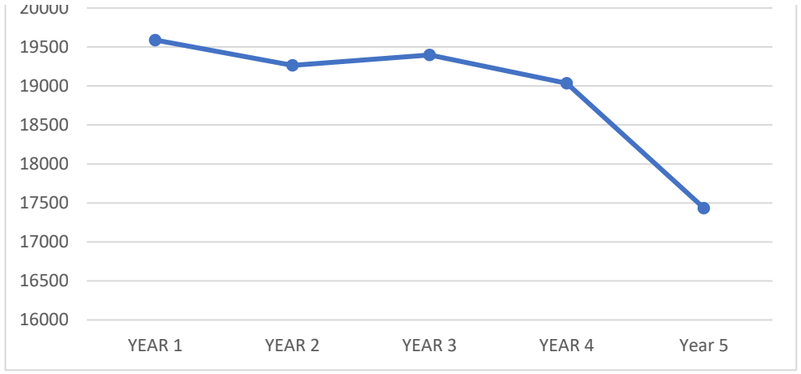
Year 3

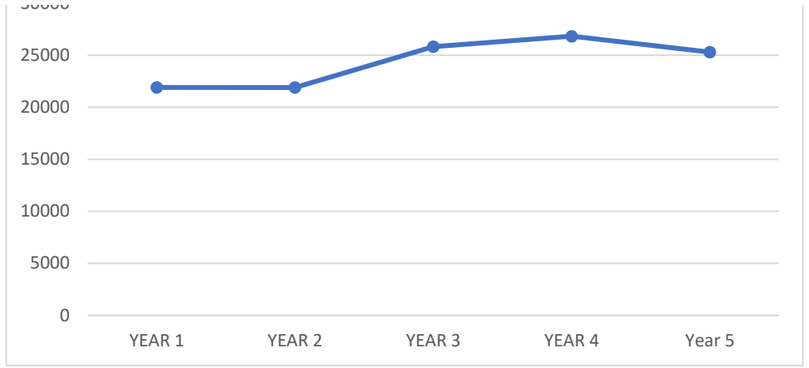




Year 4

Year 5





	Data used to Display Graph			
	NO OF COWS	REVENUE	EXPENDITURE	PROFIT
YEAR 1	97.7	41494.71734	19588.4882	21906.22914
YEAR 2	95.167	41153.5293	19264.662	21888.8673
YEAR 3	104.42874	45212.46477	19396.36447	25816.10031
YEAR 4	103.571429	45860.05623	19034.28574	26825.7705
Year 5	92.46079242	42716.94163	17434.35407	25282.58756

Year	NO OF DAIRY (	REVENUE	EXPENDITURE	PROFIT
YEAR 1	97.7	41494.71734	19588.4882	21906.22914
YEAR 2	95.167	41153.5293	19264.662	21888.8673
YEAR 3	104.42874	45212.46477	19396.36447	25816.10031
YEAR 4	103.571429	45860.05623	19034.28574	26825.7705
Year 5	92.46079242	42716.94163	17434.35407	25282.58756

	OLD COWS
11	12
10	0
9.8	9.8
9.604	9.604
9.41192	9.41192
9.2236816	9.2236816
9.03920797	9.039207968

The number of cows in the current year is given in the question

Initial Condition :

H_{11} = 9.5

C_{21}= 9.8

C_{i1}= 9.8 for i = 3 to 12

CONTINUITY CONDITIONS

$H_{1,j+1}$ = 0.95 $H_{R,j}$ For j = 1 to 4

$C_{2,j+1}$ = 0.95 $H_{1,j}$ For j = 1 to 4

$C_{i,j+1}$ = 0.98 $C_{i-1,j}$ For i = 3 to 12 For j = 1 to 4

The survival percentage of heifer and cow in the next year

Dairy cow calculation

$C_j = \sum_{i=2}^{11} C_{ij}$ For j = 1 to 5

Bullocks calculation

$B_j = \frac{1.1}{2} C_j$ For j = 1 to 5

Heifer of age 0 calculation

$H_j = \frac{1.1}{2} C_j$ For j = 1 to 5

Heifer of age 0 which were sold and reared constraint

$H_j = HS_j + HR_j$ For j = 1 to 5

PROFIT PER HEIFER	TOTAL PROFIT IN SELLING BULLOCKS IN A YEAR	TOTAL PROFIT IN SELLING HEIFER IN A YEAR	TOTAL PROFIT
40	1612.05	1237.4	2849.45
40	1570.2555	1630.29692	3200.55242
40	1723.07421	2297.43228	4020.50649
40	1708.928578	2278.57144	3987.50002
40	1525.603075	2034.13744	3559.74051
TOTAL	8139.911363	9477.83808	
ALVES	17617.74944		

Profit from selling Bullocks

PB_j = 30B_j For j = 1 to 5

Profit from selling Heifers

PH_j = 40HR_j For j = 1 to 5

Grain Acre constraint Based on Group

$GAG1_j$<=20 For j = 1 to 5

$GAG2_j$<=30 For j = 1 to 5

$GAG3_j$<=20 For j = 1 to 5

$GAG4_j$<=10 For j = 1 to 5

GROUP 3	GROUP 4	TOTAL
0	0	22
0	0	22
0	0	24.82166155
0	0	22

No of Grains in Ton cultivated in each year

Variables

H_{1j} - No of heifers of age 1 in the year j.

C_{ij} - No of dairy cows of age i in the year j.

B_j – No of bullocks of age 0 in the year j.

H_{0j} – No of heifers of age 0 in the year j.

HS_j – No of heifers of age 0 which were sold.

HR_j – No of heifers of age 0 which were reared.

PB_j – Profit on selling Bullocks of age 0 in the year j.

PH_j – profit on selling Heifers of age 0 in the year j.

PM_j -profit on selling milk from dairy cows in the year j.

GAG_{ij} – No of Grain grown in Acres in the group i and in the year j

GA_j – No of Grain grown in Acres in the year j.

GT_j – No of Grain in Tons cultivated in the year j.

GTC_j – No of Grain in Tons which were cultivated used to feed cows in the year j.

GTS_j – No of Grain in Tons which were cultivated in farm.

GTB_j –No of Grain in Tons bought to feed cows in the year j.

$GTBC_j$ – Cost to buy grain to feed cows in the year j.

$GTSP_j$ - Grain in Tons which were cultivated in farm and sold for profit in the year j.

SBT_j – No of Sugar Beet in Tons cultivated from farm in the year j.

SBA_j – No of acres used to grow sugar beet in the year j.

$SBTC_j$ – No of sugar beet tons cultivated used to feed cow in the year j.

$SBTS_j$ – No of sugar beet in tons sold in the year j.

$SBTB_j$ – No of sugar beet in tons which were bought in the year j.

$SBTBC_j$ – cost to buy sugar beet in the year j.

$SBTSP_j$ – profit on selling sugar beet in the year j.

HA_j – Acres used by heifers in the year j.

ADC_j – Additional accommodation needed in the year j.

$ADCC_j$ – Additional accommodation cost in the year j.

ADL_j – Additional labour needed in the year j.

$ADLC_j$ – Addition labour cost in the year j.

OTC_j – other cost in the year j.

$Revenue_j$ - Revenue in the year j.

$Expenditure_j$ - expenditure in the year j.

$Profit_j$ - profit in the year j.

j = 1,2,3,4,5 represents the year

0	0	22

No of Grains in Ton cultivated in each year

GT_j = 1.1$GAG1_j$+0.9 $GAG2_j$+0.8$GAG3_j$+0.65$GAG4_j$
For j = 1 to 5

GRAIN WHICH WERE GROWN IN A YEAR
22
22
=24.8216616
22
22

Grain grown is equal to the the grain used to feed cow and the grain which were sold
$GT_j = GTC_j + GTS_j$ For j = 1 to 5

Grain Consumed by cow constraint
$0.6C_j <= GTC_j + GTB_j$ For j = 1 to 5

Cost to buy Grain
$GTBC_j$ = 90 GTB_j For j = 1 to 5

Profit on selling Grain
$GTSP_j$ = 75 GTS_j For j = 1 to 5

SUGAR BEET GROWN	SUGAR BEET GROWN PER ACRE	NO OF ACRE USED TO GROW SUGAR BEET IN A YEAR
91.15323	1.5	60.76882
94.0083975	1.5	62.672265
=97.6500165	1.5	65.100011
114.642857	1.5	76.428571
131.308812	1.5	87.539208

Sugar Beet in Acre converted into Ton
SBT_j = 1.5 SBA_j For j = 1 to 5

Sugar beet consumed by cow and sold constraint
$SBT_j = SBTC_j + SBTS_j$ For j = 1 to 5

Sugar Beet Consumed by cow
$0.7C_j <= SBTC_j + SBTB_j$ For j = 1 to 5

The cost to buy sugar beet to feed cow
$SBTBC_j$ = 70 $SBTB_j$ For j = 1 to 5

Profit on selling sugar Beet

ADDITIONAL LABOUR NEEDED	ADDITIONAL LABOUR COST PER HOUR	ADDITIONAL LABOUR COST IN A YEAR	INITIAL CAPACITY COST	TOTAL COST
0	1.2	0	4000	4000
0	1.2	0	4000	4000
0	1.2	0	4000	4000
0	1.2	0	4000	4000
0	1.2	0	4000	4000
			TOTAL COST IN LABOUR	20000

Labour constraint

$42C_j+10HR_j+10H_{1j}+4GA_j+14SBA_j <= 5500 + ADL_j$

For j = 1 to 5

Additional Labour cost

$ADLC_j = 1.2ADL_j$ For j = 1 to 5