ASSESSMENT OF SMALL SCALE IRRIGATION USING COMPARATIVE PERFORMANCE INDICATORS ON SOME SELECTED FARMS IN UPPER AWASH RIVER VALLEY

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INTRODUCTION

Statements of the problem

- Large scale irrigations
  - suffer from water management practices
  - do not fit the plots of smallholders,
  - too expensive (capital or running costs)
- Unlike large scale irrigations
  - given little attention
    - on development, operation, management and improvement (EARO, 2002)
- No reliable data
  - on the area of SSI
  - estimates about 20,000 ha
  - can expand to 35,000 ha (Halcrow, 1989)
- Recently, expanding through
  - NGOs, farmer cooperatives, private investors and individual farmers

Intro..(Cont'd)

- One challenge to Ethiopia
  - to improve performance of SSI
- Because
  - provide food for the country's growing population
  - have the potential to waste, degrade resources
- Availability of information like
  - farmer fields or
  - for entire river basins
    - not common
- Data
  - to quantify performance indicators are rarely collected
- To make a performance-oriented approach effective
  - necessary to develop
    - new techniques and approaches to existing management practices
- IWMI
  - suggests "***comparative performance indicators***"

Intro..(Cont'd)

- Aim of comparative indicators
  - to evaluate outputs and impacts of IM practices,
  - interventions across different systems and system levels
  - to compare irrigation across seasons and technologies
  - are small, not data-intensive, are cost-effective (Kloezen and Garces-Restrepo, 1998)

- Besides, poor performance of the irrigations
  - evaluation of SSI, not common
  - particularly, using the *comparative performance indicators*

- Hence, this study attempts
  - introduce the concept (with some process indicators)
  - to evaluate the performance of SSI in the Upper Awash Valley

Objectives

- To compare the selected small-scale irrigated schemes using comparative performance indicators
- To evaluate the performance of selected small-scale irrigated farms in relation to water balance ratios and,
- To generate baseline information for further performance evaluation

Comparative Performance Indicators (an overview)

- Irrigated agriculture deals with
  - water and agricultural production
  - possible to develop
    - a set of external indicators for cross-system comparison

- The indicators will allow for comparison between
  - countries and regions
  - different infrastructure and management types
  - different environments, and
  - assessment of the trend in performance of a specific project

- Allow initial screening of systems
  - that perform well and that do not
- Designed to show gross relationships and trends
- Useful in indicating where detailed study should take place
- Audience for these indicators
  - policy makers and managers, and researchers

Indicators of Irrigated Agricultural Output

- The four basic comparative performance indicators relate output to unit land and water

$$Output\ per\ cropped\ area = \frac{Production}{Irrigated\ Cropped\ area}$$

$$Output\ per\ unit\ command\ area = \frac{Production}{Command\ area}$$

$$Output\ \ per\ \ irrigation\ \ supply = \frac{Production}{Diverted\ \ irrigtion\ \ \ supply}$$

$$Output\ \ per\ unit\ \ water\ \ consumed\ = \frac{Production}{Volume\ \ of\ \ water\ \ consumed\ \ by\ ET}$$

RWS & RIS are used as the basic water supply indicators

$$Relative \quad water \quad supply = \frac{Total \quad water \quad supply}{Crop \quad demand}$$

$$Relative \quad irrigation \quad supply = \frac{Irrigation \quad supply}{Irrigation \quad demand}$$

WDC is an indication of the irrigation infrastructure, by comparing the canal conveyance capacity to peak consumptive demands

$$WDC\ (\%) = \frac{Canal \ capacity \ to \ deliver \ water \ at \ system \ head}{Peak \ consumptiv \ e \ demand}$$

The two financial indicators

$$Gross\ return\ \ on\ Investment\ (\%) = \frac{Production}{Cost\ of\ irrigation\ \ structure}$$

$$Financial\ self\ sufficency = \frac{Revenue\ from\ Irrigation\ service\ fees}{Total\ O\ \&\ M\ expenditure}$$

MATERIALS AND METHODS

The Study areas

- Batu Degaga Irrigation Project
  - Location
  - Establishment
  - Organizational setup
  - Climate
  - Water sources and abstraction
  - Water distribution system

- Doni Kombi Irrigation Project
  - Establishment
  - Location
  - Climate
  - Water sources and abstraction

Data collection methodologies

- Primary data collection
  - Field observations
  - Moisture contents
  - Determination amount of water applied
  - Discharge determination
  - Soil samples collection
- Secondary data collection
  - Crop Production
  - Climatic data
  - Investment costs
  - Interview
    - 10 farmers each from head, middle and end water users

Data analysis techniques

- Laboratory analyses
  - BD, textures, pH, EC_e, FC, PWP
  - Gravimetric moisture content determination
- CropWat
  - CWR,
  - IR and Scheduling
- Questionnaire
  - 30 farmers from each scheme
- Comparative Performance Indicators
- Irrigation Water Efficiencies

Comparative Performance Indicators

- Rely on the availability of secondary data
- Not complete , consistent,
- Have different natures , types
  - Limits the application of all the nine parameters
- Hence, to compare the two-irrigation projects, minimum sets of external indicators were applied

- Based on minimum set of performance indicators
  - Evaluation of each project for individual performance
  - Comparison of the two irrigation projects and
  - Trend performance were studied

Evaluation of the individual irrigation projects

- *Relative Water Supply (RWS),*
- *Relative Irrigation Supply (RIS),*
- *Water Delivery Capacity (WDC),*
- *Gross Return on Investment (GRI)*

- They are meant to characterize the individual system with respect to water supply and finances (Molden et al, 1998)

Comparison of the two irrigation projects

- Output per cropped area
- Output per unit command area
- Output per unit irrigation supply
- Output per unit water consumed

- To compare the two irrigation projects, these indicators were used because these “external” indicators provide the basis for comparison of irrigated agriculture performances across systems (Molden et al, 1998)
  - The first two parameters were calculated for of the year 2003 of the two projects

Trend Performances of the two irrigation projects

- If the minimum set of external indicators is disaggregated in time and space, they serve as tools for internal management of irrigation systems and for evaluating impacts of interventions (Molden et al, 1998)

- Financial Self Sufficiency's of each irrigation projects
  - 11 years for Batu Degaga while 6 years period Doni irrigation project

Farmer's field evaluation in each scheme

- Application, Storage and Distribution efficiencies

$$E_a = \frac{Depth \ of \ water \ added \ to \ the \ root \ zone}{Depth \ of \ water \ applied \ to \ the \ field}$$

$$E_r = \frac{Volume \ of \ water \ added \ to \ the \ root \ zone \ storage}{Potential \ soil \ moisture \ storage \ volume}$$

$$C_u = 100 \times \left(1.00 - \frac{\sum |d|}{n \overline{X}} \right)$$

RESULTS AND DISCUSSION

Features and computed values of some parameters of the two Irrigation Projects

Irrigation project	*Irrigation system*	*Design Capacity lit/sec*	*Maximum Canal capacity, lit/sec*	*Average discharge, l/s*	*Developed area, ha*	*Actual irrigable area, ha*
Doni	Diversion	368	400	200	195	122
Batu	Pump*	280	300	170**	140	60

Investment costs of the two selected Irrigation Projects

Site name	*Area developed, ha*	*Actual irrigable area, ha*	*Year completed*	*Service year*	*Distribution structures cost ('000)*	*Cost per hectare, birr/ha*	*Average interest rate %*	*Construction cost for the present year (PNW)*
Batu D.	140	60	1992	20	669.19	11,153.2	10.5*	36, 961.26
Doni K.	195	122	1997	20	1,104.90	9,056.6	10.5*	18,217.93

Total yield and land coverage of Batu Degaga and Doni irrigation projects for the year 2003

Crop	*Batu Degaga*				*Doni*		
	Area (ha)	*Yield (qt)*	*Ave. Price, birr/kg*	*Total Income (birr)*	*Area (ha)*	*Yield (qt)*	*Total Income (birr)*
Onion	19.69	1,097.73	1.58	173,441.34	72.00	3,768.44	595,413.52
Tomato	2.38	32.00	0.73	2336.00	18.50	254.33	17,803.10
Maize	52.25	2,292.00	0.90	206,280.00	47.00	2,007.70	180,693.00
Pepper	2.45	4.25	0.50	212.50	4.75	11.00	5,500.00
Popcorn	1.94	16.00	2.50	4,000.00	-	-	-
Bean	6.50	94.00	1.20	11,280.00	12.00	171.50	20,580.00
Perennial crops	-	-	-	-	30.00	-	106,000
Total	**79.08**	**3,535.98**		**397,549.84**	**184.50**		**925,989.62**

Total yields and land coverage of Batu Degaga and Doni irrigation projects for the 2003/2004 cropping season (Oct-Feb.)

Crop	*Batu Degaga*				*Doni*		
	Area (ha)	*Yield (qt)*	*Ave. Price, birr/kg*	*Total Income (birr)*	*Area (ha)*	*Yield (qt)*	*Total Income (birr)*
Tomato	3.3	228.97	1.15	26,331.55	13.00	740.00	85,100.00
Onion	30.6	4,751.73	1.51	717,511.23	65.25	6,874.80	1,038,094.80
Pepper	1.8	35.00	0.50	1,750.00	2.75	53.50	2,675.00
Popcorn	8.0	66.00	2.50	16,500.00	-	-	-
Maize	15.1	663.46	0.90	59,711.40	8.25	509.75	45,877.50
Perennial*	-				30.00	-	35,333.33
Total	**58.8**	**5,745.16**		**821,804.18**	**119.25**		**1,207,080.63**

*: Is the sum of mango, sugarcane and orange

Evaluation of the individual irrigation projects

- *RWS, RIS, WDC & GRI were* used to evaluate & characterize the performance of individual irrigation projects separately

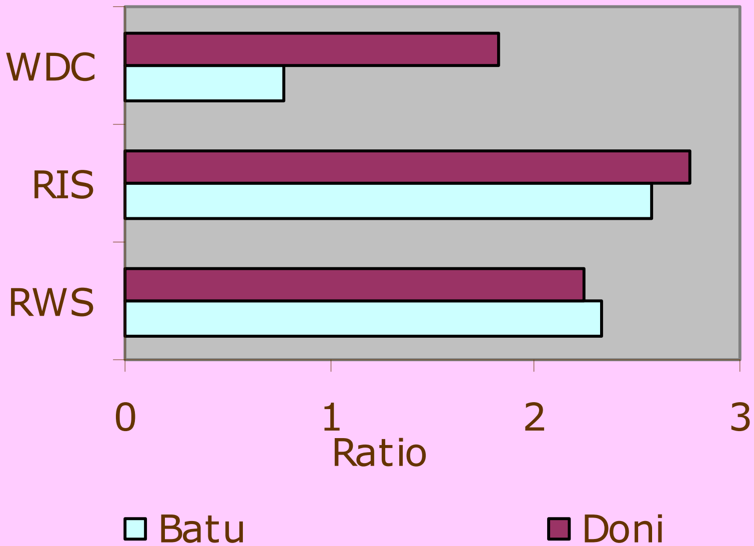
RESULTS OF SOME PARAMETERS FOR CROPPING SEASON 2003/2004

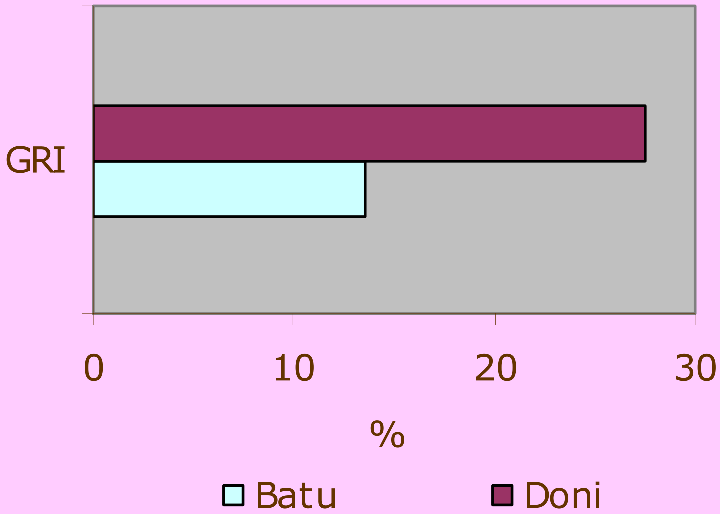
Site	*Command area, ha*	*Production 2003/2004, birr*	*Irrigation supply,* M^3	*Irrigation supply,* mm	*CWR, mm*	*IR, mm*	*Peak IR, l/sec/ha & lit/sec*	*Canal capacity, l/sec*	*Total RF, mm*
Batu	58.75	397,549.84	722,160	1,229.20	571.82	477.61	1.56= 219.96	170.00	94.80
Doni	119.00	925,989.62	1,797,120	1510.18	722.56	547.76	0.92= 109.48	200.00	106.70

Summary of results for RWS, RIS, WDC and GRI

Site	*RWS, ratio*	*RIS, ratio*	*WDC, ratio*	*GRI*, %*
Batu Degaga	2.32	2.57	0.77	13.60
Doni	2.24	2.76	1.83	27.55

*GRI was calculated based on the 2003 productions.





- RWS and RIS are higher than 2
  - indicated that there was a generous supply of water and
  - the sole water provider was irrigation,
- WDC at Batu Degaga is less than 1
  - so, the capacity of the pumps at peak time of crop demand is below the requirements
- WDC of Doni is higher than 1
  - so the canal capacity is not a constraint to meet crop water demands
- GRI of Batu Batu 13.6% and 27.55% for Doni
  - indicated that Doni has higher rate of return on investment than Batu

Comparison of the two irrigation projects

- To compare the two selected irrigation projects in terms of their output per area and water supply, four comparative indicators were used

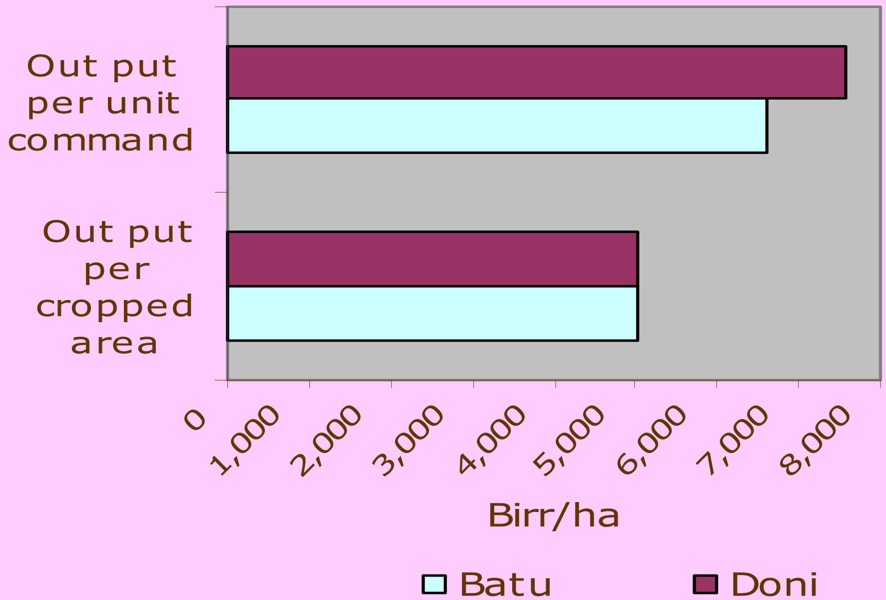
Cropped areas, irrigation water and yield of Batu and Doni irrigation projects.

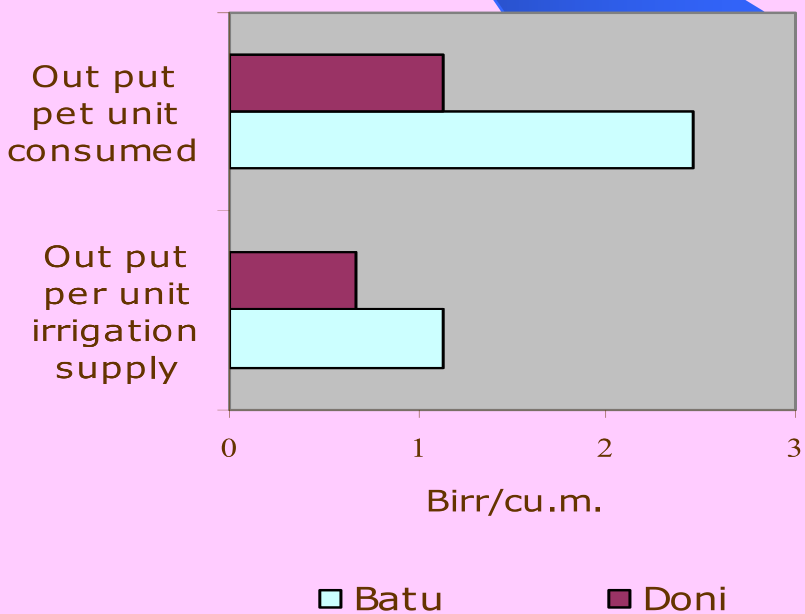
Site	*Cropped area, ha*	*Command area, ha*	*Water consumed, m^3/season*	*Irrigation supplied, m^3/season*	*Production, birr*	
					For year 2003	For 2003/2004 cropping season
Batu	79.08	60	335,944.25	722,160.00	397,549.84	821,804.18
Doni	184.50	122	859,846.40	1,797,120.00	925,989.62	1,207,080.83

Summary of calculated parameters for Batu Degaga and Doni

Site	*Output per cropped area, birr/ha*	*Output per unit command, birr/ha*	*Output per unit irrigation supply*, birr/m³*	*Output per unit water consumed*, birr/m³*
Batu	5,027.25	6,625.83	1.14	2.45
Doni	5,018.90	7,590.00	0.67	1.14

*These values were computed for the cropping season 2003/2004





- Output per cropped area of the two projects are more or less equal

- Output per command area of Doni (7,590.00) is greater than Batu (6,625.83).
  - Due to cropping intensities (Batu 132% and Doni 151%) and
  - type of crop grown (onion, Doni 39% and Batu 25%).

- Output per unit irrigation supply, Batu was 1.14 and Doni was 0.67
  - indicates that irrigation water was more abundant at Doni than Batu and
  - water was used to produce more at Batu

Trend performance of each scheme

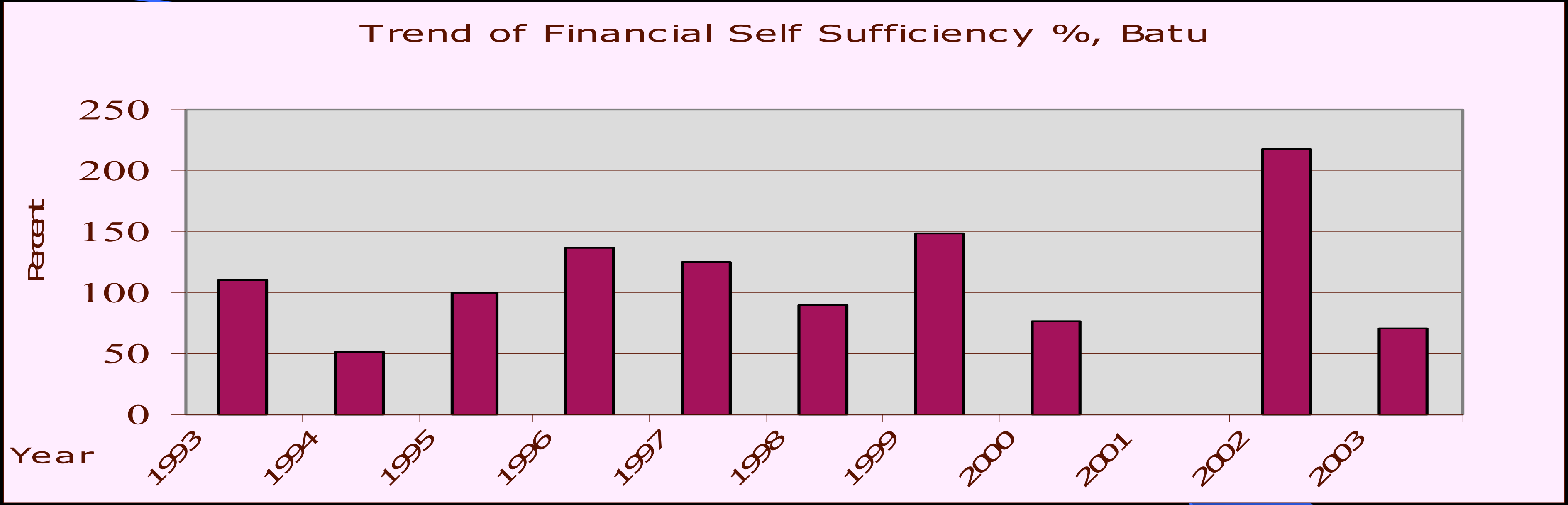
Batu Degaga Trend of Financial Self Sufficiency

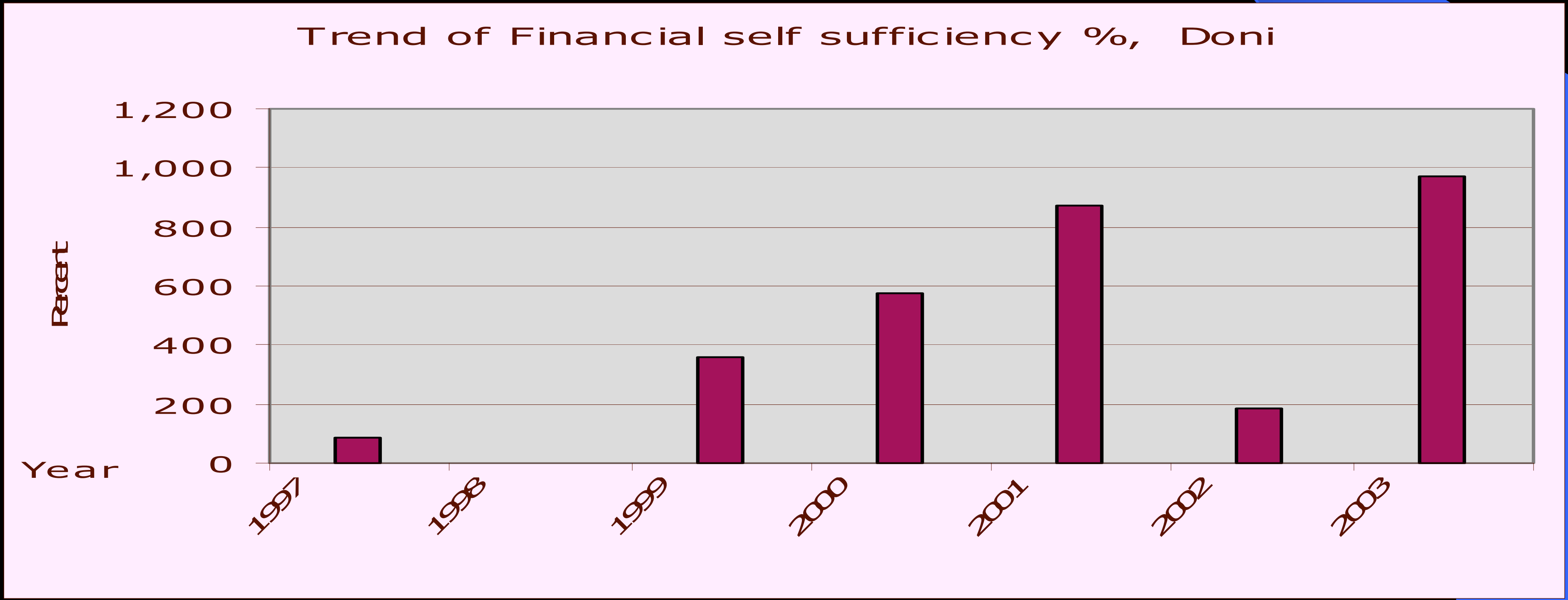
Year	*Total Revenue, birr*	*Total O & M, birr*	*Financial self sufficiency %*
1993	4,458.00	4,041.00	110.32
1994	8,808.00	17,283.83	50.96
1995	14,765.00	14,861.26	99.35
1996	27,638.30	20,297.29	136.17
1997	38,681.55	30,934.40	125.04
1998	33,532.20	37,144.09	90.28
1999	35,962.00	24,305.91	147.96
2000	33,020.05	43,203.53	76.43
2001*	0.00*	0.00	0.00
2002	30,727.00	14,106.00	217.83
2003	28,721.00	40,413.47	71.07

* No irrigation

Doni Trend of Financial Self Sufficiency

Year	*Total Revenue, birr*	*Total O & M, birr*	*Financial self sufficiency %*
1997	1,693	1,986	85.25
1998	0.00	0.00	0.00
1999	2,288	634	360.88
2000	13,866	2,417.2	573.64
2001	12,189	1,394.5	874.08
2002	12151	6,523.9	186.25
2003	25,952	2,674.1	970.49


Trend of Financial Self Sufficiency %, Batu
250
200
150
100
50
0
Percent
Year
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003


Trend of Financial self sufficiency %, Doni
1,200
1,000
800
600
400
200
0
Percent
Year
1997
1998
1999
2000
2001
2002
2003

Farmer’s fields evaluation at each irrigation projects for their efficiencies

Physical soil properties of selected fields of Batu Degaga irrigation project

Farmer's name	*Soil depth cm*	*pH*	*Bulk Density gm/cm³*	*EC_e, dSm*	*FC %*	*PWP %*	***Soil texture class***
Bati	0-30	7.31	1.03	0.69	26.68	18.88	Silt loam
	30-60	7.35	0.95	0.71	24.69	18.14	Silt loam
	60-90	7.30	1.01	0.71	24.09	19.43	Silt loam
Bejiga	0-30	6.88	1.02	0.39	25.63	18.29	Silt loam
	30-60	7.09	0.96	0.46	24.98	18.13	Silt loam
	60-90	7.16	1.02	0.52	24.18	19.50	Silt loam
Taddese	0-30	7.20	1.21	0.80	28.48	19.32	Silt loam
	30-60	7.31	1.05	0.83	28.53	19.75	Silt loam
	60-90	7.36	1.04	0.82	25.90	19.56	Silt loam

Physical soil properties of selected fields of Doni irrigation project

Farmer's name	Soil depth cm	pH	Bulk Density gm/cm^3	EC_e, dSm	FC %	PWP %	**Soil texture class**
Dergu	0-30	**7.13**	1.04	0.66	21.66	14.05	Loam
	30-60	7.19	1.12	0.74	20.97	16.4.0	Loam
	60-90	6.98	1.08	0.63	25.73	15.98	Loam
Arega	0-30	6.92	0.98	0.52	23.23	16.31	Silt loam
	30-60	6.76	0.91	0.43	23.51	19.01	Silt loam
	60-90	6.72	0.96	0.40	24.34	19.19	Silt loam
Assefa	0-30	7.38	1.25	0.93	20.41	15.66	Loam

Applied irrigation water measurement (Flume average) at Batu Degaga

Farmer's name (Batu)	*Time elapsed (sec)*	*Flume height (cm)*	*Respective discharge (lit/sec)*	*Areas of fields (m2)*	*Total volume (lit)*	*Depth applied (mm)*
Bati	14,910.00	15.00	9.40	2,520.0	140,154.o	55.62
Bejiga	11,250.00	14.50	8.95	1,652.0	99,180.0	60.04
Taddese	8,092.25	14.75	9.18	1,224.3	74,287.4	60.68

Applied irrigation water measurement (Flume average) at Doni

Farmer's name (Doni)	*Time elapsed (sec)*	*Flume height (cm)*	*Respective discharge (lit/sec)*	*Areas of fields (m^2)*	*Total volume (lit)*	*Depth applied (mm)*
Dergu	8,151.95	8.67	4.03	720.65	32,852.33	46.97
Arega	4,035.25	11.40	6.24	589.57	25,179.96	42.71
Assefa	7,369.00	8.00	3.50	810.23	25,791.50	31.83

Average soil moisture contents before and two days after irrigation at Batu, % of dry weight

Batu Degaga	*Time of soil sampling*	*Soil moisture contents, % of dry weight*		
		Soil depths, cm		
		0-30	30-60	60-90
Bati	Before irrigation	27.51	29.49	31.50
	After irrigation	34.16	33.76	33.47
Bejiga	Before irrigation	22.60	24.53	25.86
	After irrigation	28.72	28.57	28.95
Taddese	Before irrigation	20.60	25.28	28.99
	After irrigation	27.66	29.41	30.07

Average soil moisture contents before and two days after irrigation, % of dry weight at Doni

DONI	*Time of soil sampling*	*Soil moisture contents,* % of dry weight *Soil depths, cm*		
		0-30	30-60	60-90
Dergu	Before irrigation	17.72	17.51	19.23
	After irrigation	22.47	20.64	21.2
Arega	Before irrigation	28.68	28.42	29.14
	After irrigation	32.85	33.14	33.43
Assefa	Before irrigation	23.39	-	-
	After irrigation	26.06	-	-

Calculated efficiencies of selected fields at Batu Degaga irrigation project

	Efficiencies, %		
Farmer's field	Application	Storage	Distribution
Bati	59.00	100.00	100
Bejiga	50.60	95.96	100
Taddese	64.29	84.58	100

Calculated efficiencies of selected fields at Doni irrigation project

	Efficiencies, %		
Farmer's field	Application	Storage	Distribution
Dergu	53.75	80.41	100
Arega	58.87	98.67	100
Assefa	31.46	104.70	100

SUMMARY AND CONCLUSION

- The evaluation and characterization of the two irrigation projects individually indicated that irrigation water is not a constraint at farm level

- Higher amount of water is diverted (generous supply of water) at Doni than Batu

- At Doni there is also high rate of return on investment than Batu

- Regarding the output per area, Doni is better than Batu

- But for the output per water supply the inverse is true that is Batu Degaga (where water is a constraint) is better than Doni

- Trend analysis might give an indication on how the two irrigation systems are different in their irrigation system, operation and management, and so on

- Since the intention of the analysis was to investigate how the performance of the irrigation projects were consistent with respect to the irrigation system,
  - Doni irrigation has been performing better than Batu

- But it does not mean that diversion is healthier than pump irrigation,
  - because it needs larger sample study and taking into consideration several situations or issues

- The three selected irrigated fields at Batu
  - can be considered as '*in the order of similar condition'* for their irrigation water management efficiencies
- But at Doni, for irrigation water,
  - Arega's plot was more efficient than Dergu's
  - Assefa's plot was the least efficient
- From the analyses irrigation water efficiencies as a whole,
  - farmers were doing good job in terms of water distribution uniformity

- The study covered the minimum set of indicators
  - small number of samples cannot permit a deep analysis of the indicators, but
  - the study showed the usefulness of the indicators

- This paper can be considered as a starting point to evaluate the performance of SSI in Ethiopia using CPI

  - and tried to demonstrate the application of the method developed by IWMI

- This paper is the result of two irrigation projects, further evaluation has to be carried out in other places to adopt and correlate the indicators with irrigation efficiencies.

RECOMMENDATIONS AND METHODOLOGICAL LESSONS

- At Batu Degaga
  - increase the capacities of pumps
  - to meet CWR at peak demand
- Designing and constructing irrigation projects has to consider the capacity and knowledge of the farmers
- Water was wasted by farmers, especially at Doni
  - so farmers should be advised high value cash crops than cereals and to get much return
- Most studies were focused on long furrows
  - further study about hydraulics of very short furrow is important

- Distribution eff. were good while application eff. were poor
  - So to improve the efficiency irrigation, scheduling has to be made and recommended
- Even if layout of the furrows has advantages on management and distribution efficiency
  - there were some indicators of salt accumulation in the furrows
- To evaluate very short furrows of SSI,
  - storage efficiency can be used with application efficiency than distribution
- Storage efficiency can tell us losses of water through deep percolation,
  - because distribution efficiencies are not problems of short furrows

- CI are very good estimator and,
- indicator of performance of irrigation projects
  - but full, reliable and consistent documentation
  - this type of study has to be adopted and practiced on some other SSI in the country.
- Assigning DA and Office assistant for the WUA importance
  - to the improvement of irrigation projects and
  - used as a mechanism to develop a healthy perception of farmers about irrigation
- Prior to developing an irrigation projects for farmers,
  - the capability of farmers
  - close monitoring than completely left the operation for them fa
  - issues like CWR have to give emphasis

- Irrigation of Diversion weir is better than Pump for FMIS for its low O & M costs

- Pump failure has been a serious problem at Batu
  - next to its running cost,
  - it needs skilled manpower

- As an opinion, advantage of Pump irrigation
  - can be used as a tool to improve perception about irrigation water that has costs and must be used efficiently

Methodological lessons

- Problems when calculating
  - discharge, production cost, income, yields and gross return on investment were encountered at each location
  - delay of payments
- Farmers did not have constant irrigation intervals
- The ability to analyze financial dimensions of the system
  - depends on the availability of a quantitative record
  - So, to interpret and understand these records, the support of the DA at both study area was very helpful
- Most of the farmer uses more than one diversion ditches , so
  - difficult to install a single parshal flume

- Besides, farmers may change the location and the direction of the ditches frequently
- Irrigation projects did not constructed based on their design
  - Both have much higher irrigable areas than actually irrigated
  - reflected on the gross return on investment
  - So designers and sponsoring agencies have to consider such condition when they develop SSI
- Overlap of seasonal cropping pattern
  - difficult to estimate exactly the total amount of water diverted and total yield produced

- Evaluating SSI using CPI is a new concept in Ethiopia
  - During preliminary survey and data collection process there were some difficulties in obtaining necessary data and
  - problems of interpreting the type of information included in the analyses
  - ***Reports of similar works of other countries played a great role in order to solve the problem***