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Water Banking for Resources Productivity and Food Security in Tigray, Ethiopia

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Abstract
This study was aimed to investigate the impact of water banking on resources productivity and improving food security of the rural farm households in Tigray, Northern Ethiopia. It was conducted in four tabias[1] and data was collect from 132 sample respondents, out of this 36% of them are female headed households. The study revealed that more 75% of the respondents are still living in subsistence rain fed agricultural production though there were abundant idle resources in the dry season. This indicated that an intervention is required to increase agricultural productivity by creating market for water and expansion of irrigation during the dry season. The study also identified that participation on water bank and irrigation has a positive and significant impact on food security by increasing the income and asset holding of the farm households during the dry season. The average annual income of the water bank participants was 1703.85 birr higher than non-participants and there was also a significant difference in the mean annual expenditure of water bank participants, 8862 birr, which was significantly higher than the non-participants, 1899 birr. The estimated result further indicated that water banking participation reduced seasonal migrations during the dry season and used as climate change adaptations. Hence, improvement and expansions of water banking can serve as a powerful agricultural intervention to increase income, diversify livelihoods and reduce vulnerability since irrigation water creates options for extended production across the year, increases agricultural productivity, and creates employment opportunities.
Keywords: water banking, food security, productivity, migration and farm households

Introduction

The agricultural production system of Ethiopia is still largely rain fed which exhibits low yields for major staple crops due to low use of irrigation and other farm inputs. Rain fed agriculture poses production risks with increased climate variability since it mainly relies on forces of nature. (B. Gebremedhin and D. Peden, 2003). This triggered agricultural failure for subsistence farmers resulted from moisture stress and frequent drought. Consequently, the country economy is characterized by seasonal hunger in the months just before the coming harvest season.

In the last three decades, food production in Ethiopia has never been sufficient to enable the populations to be food secured. Many Ethiopians live in conditions of chronic hunger with both a low average daily energy supply (kcal/capita/day) of 1880 and a very high (44%) prevalence of undernourishment (Dejene, 2008). The livelihood of the rural households in Tigray is also extensively dependent on rain fed agricultural income options supported by off-farm income generation. However, agricultural production and diversification remain low due to frequent drought. Water supply availability is highly variable across seasons and years and may become even more difficult to predict as climate change progresses (Garrick and Jacobs 2006; Williams 2007).

The average land size available to support four person's household was about 0.5 hectare, too small to support the family on rain fed agricultural production on one harvesting season in the region. As Nigatu (2004) revealed, even in years of adequate rainfall and good harvest, people remain in need of food assistance. The average cereals production (the major agricultural output) is less than 7 quintals per hectare in the drought prone areas and this level of staple cereal production can only feed a family for 5-8 months a year at best (CSA, 2005; Kidane, 2006). As a result of the food deficient situation in the region, where even in a good year farm households can only meet 60% of their total food needs and the remaining is filled by food aid-both free and Food-For-Work (FARM Africa, 1998; Sosina and H.Stein, 2007).

Although the seriousness of food shortage varied from year to year, farm households faced seasonal food shortage almost every year. This difference is triggered by low resource agricultural productivities during the dry season. Land and labor were almost idle and people were migrating for labor. Hence, to tackle such problems, introducing and expansions of water banks could enhance the productivities of the agricultural resources and improve the income of the farm households. As Kamara et al. (2004) explained erratic rainfall have created uncertainty for agricultural production and hence emphasized a call for irrigation in Africa.

Water banking is a new management approach to manage water resources with the ability to test and assess the impact of options for the allocation of limited water resources. Water banking can open the

[1] tabia is the smallest administrative hierarchy in Tigray (Region-Zone-Woreda/District-tabia)

opportunity to release water from head dams at the beginning of the water year to mimic the natural flow and subsequently stored in the aquifer or to fill the water bank. Water banking objectives and definition are completely diverse in the literature according to the authors or owners perspectives and the reason of use ("Idaho Water Resources Board" 1999, Laurent et al 2001, Klamath basin; Christine 2002, and Water Bank Company in the UK 2004). The common definition of the water bank is the foremost marketplace for trading, buying and selling water assets including water rights and water utilities (Water Bank Com, 2005).

However, this definition is not matched with this study objective. Hence, in this study, water bank was considered as store water in aquifer as an underground dam during the high flow and wet season/year, to be released during drought or dry conditions; or it is making water available for new uses: both in stream, and out of stream.

Many studies have been done on the water harvestings, and water shade management at larger scale irrigations. However, given the potentially high rewards, but also high possibility of failure, the assessment of irrigation and water banking potential must go beyond the scale of irrigation to integrate concerns regarding environmental sustainability, resource use efficiency, and food security impacts (Berhanu and Pender). As to my knowledge, none of these studies have addressed the role of water banks on resource productivities such as labor and land productivity and reducing seasonal migrations at household level in Tigray, Northern Ethiopia. Hence, this study was intended to fill the gaps of the existing literatures by examining the impact of water banks on rural farmer's resource productivities and food security in response to water scarcity and examined the role of water banking technologies for climate change adaptation and reducing seasonal migration.

Objective of the study

The objective of this study was to investigate the impact of water banking on agricultural productivity; identify the contribution of water banking on food security and seasonal migration of rural households; investigate the synergies between water banking and climate changes adaptation. Finally, to provide recommendation on water banking utilization and expansions throughout the water scare areas of Ethiopia

Methodology

Description of the study area and sample designe

Tigray region has six administrative zones and four agro-climatic zones: Kolla (semi-arid), Woina-Dega (warm temperate), Dega (temperate) and Wurchi (cold). This study was conducted in kiltewalte woredas of Eastern Zone of Tigray, Northern Ethiopia in 2014. The study woreda was selected purposively based on the availability of water bank and irrigation practices, infrastructure availability and nearer to regional and Wereda markets. The study area was characterized by subsistence farming with erratic rainfall and drought prone pose serious threat on households' food security, Bureau of Agriculture and Rural Development (BoARD, 2012).

Primary data were collected through a household survey and qualitative field observations. For the household survey, a stratified multi-stage sampling design was employed within the wereda. First, all tabias (sub-districts) in the selected wereda were listed, and four tabias were purposively selected based on their irrigation activities and infrastructure availabilities. Then a total of 132 sample smallholder respondents were selected using probability proportional sampling to the size of the population from each tabia. During this exploratory survey, discussions were also held with different stakeholders including local administrators, farmers' cooperatives and development agents. The distribution of sample respondents by tabias and water bank participations is summarized in Table1 below.

Table 1: Distribution of sample respondent by wereda and participation on water banks

Sample tabias	participants'	non-participants	Total sample
Adiksandid	8	41	49
Aynalem	13	13	26
Genfel	11	33	44
Addis alem	1	12	13
Sample size	**33**	**99**	**132**

A structured household questionnaire was used to collect quantitative and qualitative data on households' agricultural production, irrigation, consumption, demographics, resource ownership, and non/off-farm activities of the rural farm households in the study area.

Data analysis

Both descriptive and econometrics methods were employed to assess the determinants and impacts of participation on water banking. Descriptive methods including t-test and chi-square tests were employed to disclose and test the existence of any statistically verifiable differences among farmers participating on water banking and their counterfactuals.

Empirical model specification

Two groups of households were compared to analyze the impact of water banking on the food security of the farm households. These groups are participant households (the treatment group) and nonparticipant households (the control group). The non-participant households were used as a comparison group to examine the impact of the water bank on participant households in the study area. The outcome variables that were used for comparison, in this study, were households' mean annual income and TLU. The average change in the outcome variables was estimated using Propensity Score Matching (PSM). Participant households were matched with non-participants that were assumed to have same probability to participate in the water bank. The propensity score, probability of participation in the water banking, was estimated as a function of observable household characteristics using Logit statistical model (Abadie, 2003).

The Average Treatment Effect of the i^{th} household (ATE^i), the difference in households' income, can be expressed by: $Y_1^i - Y_0^i$ Where, Y_1^i is the income of the i^{th} participant household and Y_0^i is the income of the i^{th} non-participant household. Assuming D as household participation status in the water bank irrigation (D= 1 for participant and D = 0 for non-participant), the ATE^i in casual effect notion can be expressed by:

$$ATE^i = E\,(Y_1^i/D=1) - E\,(Y_0^i/D=0) \qquad 1$$

Where $E(Y_1^i/D=1)$ is the average income for household with access to irrigation from water bank and $E(Y_0^i/D=0)$ is the average income for household with no access to irrigation from any water bank and the Average Effect of Treatment on the Treated (ATT) can be expressed by:

$$ATT=E(Y_1^i-Y_0^i/D=1) =E(Y_1^i/D=1)-E(Y_0^i/D=1)$$

The effectiveness of matching estimators for impact evaluation rests on assumption of common support and assumption of conditional independence. The common support assumption states that, the test of the balancing property is performed only for observations with propensity score between the common support region of the participants and the nonparticipant's propensity score i.e. between 0 and 1. While, the conditional independence assumption states that, the irrigation scheme assignment condition is independent of the post-irrigation scheme outcome. Mathematically this can be expressed by: $(Y_1^i - Y_0^i) \perp (D/X_i)$ (Fafchanb vguimps, 2007).

Result and discussions

Socioeconomic Characteristics of Households

As summarized in Table 2, the mean age for the sample household heads was found to be 46.4 years with no significant difference between water bank users and non-users. This mean age is in the active labor force as the profound by (Jacobsen, 1999). From the survey, about 25% of the households were participating on irrigation and different water bank structures like river diversion, ponds/wells, tanker while the remaining 75% of the households were not- participants. 36% of the sample respondents were female headed households. With regard to the gender composition, within the female headed households 30, 30% of them were irrigation participants and 37% of them were non-participants.

The average family size for the sample households was found approximately 5 with mean landholding 2.7 tsimad. This figure was the same with the regional average family size of 5 reported by Bureau of Agriculture and rural Development (BoARD, 2012). The two sample t-test indicated that the users and non users have significant difference in family sizes. Year of schooling of the water bank user households was higher than non user households. This might be due to the fact that the irrigation users can cover the school expenses. Year of schooling could be a proxy measure of livelihood management decisions by the households. The average cultivated land size of the participants was higher than the non-users by 0.41 tsimad though the difference was insignificant. This was expected, since the farmers have almost the same land holding and the small difference is due to the fact the users can rent in or shared in farmland from nonusers since they have higher income from irrigation.

Distance to local market and Farmers Training Center (FTC) were also important variables in irrigation participation and farm input access. The average time taken to the local market and FTC was 77.62 and 48.48 minutes respectively on foot and the mean frequency of Development Agent (DA) contact was 5 days/ year. We found also more than 97% of the sample households participated on irrigation packages and rural institutions like saving, credit and cooperatives institutions. The participation in rural institution is an opportunity for irrigation participation as these institutions are sources of finance and information to increase agricultural productivity.

Table 2: Characteristics of water bank participants and non-participants

Variables	Participants' Mean	non-participants mean	total mean	t-vale
Age	45.4 (13.59)	46.7 (13.65)	46.38(13.59)	0.64
Family size	6.12(2.22)	5.24(2.09)	5.46 (2.15)	0.0***
Years schooling	3.30 (3.42)	2.72(3.19)	2.87(3.24)	0.38
Livestock (TLU)[1]	2.82(2.79)	2.20(1.68)	2.35(2.03)	0.05**
Farm cultivated tsimad[2]	2.91(1.64)	2.50(1.31)	2.60(1.40)	0.14
Distance to local market	78.48(42.13)	76.76(33.27)	77.19 (35.53)	0.81
Time taken to FTC	39.09 (26.99)	57.87(25.60)	53.18(27.11)	0.023**

*, ** and *** denote significance at 10%, 5% and 1% respectively.
The values in the parenthesis are the standard error
Source (Authors survey, 2014)

Households' expenditure and income

As summarized in Table 3, there was a significant difference in the mean annual expenditure of water bank participants with 8862 EBR and non-participants with 1899 ETB. The farm income was also significantly higher for users, by 2751.848 ETB than non users, of the water banking in the study area. There was also a significant difference in livestock income between users and non-users of the irrigation from water bank. Household's participation in non-farm activities also seems to have an impact on irrigation participation. Those farm households who participated on irrigation have lower non farm income from non-participants. This might be because the participants invest most of their time on their own agricultural productions and they did not migrate to other areas for searching of labor.

Table 3: Consumption expenditure, and income of irrigation users and non-users

Variables	participants' mean	non-participants' mean	total mean	t-vale
Total expenditure	8861.86(11953.45)	1898.98(5663.99)	3639.70(8249.99)	0.00***
Off farm income	2819.39(674.06)	4191.02 (664.73)	3848.114(527.60)	1.127
Livestock income	3301.81(1334.81)	1455.53(2150.6)	1917.1(4297.28)	0.032**
Crop income	7291.67(1117.64)	5853.48(412.30)	6213.03(417.87)	0.026**
Farm income	18021.24(2270.68)	15269.39(1014.26)	15957.36(950.21)	0.039**

*, ** and *** denote significance at 10%, 5% and 1% respectively.
The values in the parenthesis are the standard error
Source (Authors survey, 2014).

Water banking and farmers' willingness to participate

About 79% of the water bank participants use river diversion, wells and ponds for irrigation. 75 % of the water banks were constructed by NGOs and government. About 58 % of the sample respondents used water pump for irrigation. On average, the first and second round irrigation potential was 2.2 and 2 tsimad respectively. But, the first and second actual irrigated farm size was 1.5 and 0.6 tsimad respectively. This revealed that about 31% and 70 % of the farm was un-irrigated in the first and second round irrigations respectively. This indicated the actual irrigated farm size was below the potential irrigation and farmers were not allocatively efficient in using the resource they have. This suggested that an intervention of water marketing between the water bank owners and non owners but irrigation water demanders is required.

Given the awareness of the farmers, property right of the water bank and availability of farmland, the farmers who have not an irrigation access were willing to participate in irrigation and their average willingness to pay was about 3847 ETB and the average willingness to sale/receive by the water bank holders was 1590 ETB to irrigate one tsimad of farm land for one harvest. About 55% of the irrigation users were willing to sell water and about 79 % of the non-participants were willing to buy water for irrigation though there was no any marketing of water in the study areas. This indicated there is a higher demand for water banking and it is possible to generate a market between the water bank owners and non-owners, though most of the water banks were communal and arrangement of well defined property right of the water bank is required.

Hence, water banking has proven to enhance agricultural productivity and improve the livelihoods of

[1] TLU (Tropical Livestock Unit) is international animal resources measurement unit wherein 1 TLU equals 1 camel, 0.7 cows, 0.8 oxen, 0.1 sheep/goat, 0.5 donkeys, 0.45 heifer/bull, 0.7 mule/ horse, 0.2 bee colonies or 0.01 chickens (Randela et al. 2000).
[2] Tsimad is 0.25 Hectare

the farm households by allocation of water and labor in the agriculture dependent farm households. Participants on water banking and irrigation have produced additional 8 quintals per hectare in stable crop production than non-participants. As result, irrigation participation has increased agricultural production and helped to use the household resources throughout the year. This was in line with findings of Domenech et.al (2013) availability, access, and use of water for irrigation can increase agricultural productivity significantly, especially during the dry season. Irrigated maize yields could increase by 141–195 percent and paddy yields by 270–283 percent, compared to rain fed yields based on an ex ante smallholder irrigation technology assessment by Agricultural Water Management (AWM) solutions project. Irrigation also influences time use, nutrition and health outcomes and women's status; and environmental outcomes (ibid)

Water banks have also an effect on reducing soil erosion and adapting climate change risks. The survey result revealed that about 44 % of the respondents' supposed that the water bank has an advantage to reduce flood, improve soil fertility and increase land and labor productivity. This study finding also show that water bank has the potential to reduced seasonal migrations by 11%.

Challenges and constraints of water banking and irrigation

Identifying challenges and constraints confronting farmers for water bank and irrigation participation helps to design appropriate policy interventions to foster agricultural productivity and reduce the risk of rainfall variations. As shown in Table 4, resource related challenges such as shortage of water for irrigation, lack/small size of farm land and lack of household labor have mentioned as challenges to participate on water banking.

Agricultural input and output markets problems were among the other major constraints of water bank participation. In this regards lack of market for the produce, price fluctuation and expensiveness of inputs (like fuel cost, fertilizer and associated inputs) were mentioned as a bottleneck of irrigation participation as these factors have an impact on agricultural productivity. The inability of the local market to absorb the quantity produced and technical problem on water bank construction were also found as serious challenge of irrigation. This phenomenon leads to discourage farmers' production of market oriented crops particular for vegetables and fruits. Access to market information, especially price information was essential to enhance bargaining powers of farmers and produced demand oriented crops. There was also complains of price volatility of agricultural commodities over time which hindered agricultural productivity.

Bio-physical problems like land size, malaria expansion, and slop of the farm land have mentioned as constraints of irrigation access from the water banks though they are not statistically significant. Lack of well-defined property right on water banks and no/low institutional arrangement on water utilization for irrigation were among the other challenges of participating on water baking.

Table 4: Challenges and Constraints of participation on irrigation and water bank

Variables	Participants	non-participants	sample	X^2
Lack of awareness	96.97%	97.98%	97.73%	0.736
Lack of water for irrigation	96.97%	94.95%	95.45%	0.01***
Shortage farm land for irrigation	66.67%	52.53%	56.06%	0.156
Expensive rent water pump/ fuel	87.88%	94.95%	93.18 %	0.163
Lack of market for produce	57.58 %	49.49%	51.52 %	0.421
Low price of output	56.20%	43.80%	63.35%	0.02**
Expensive inputs	87.88%	95.96%	93.94%	0.09*
Shortage of labor	93.94 %	88.78%	90.08%	0.391
Environmental safety/ malaria	3.03%	2.02%	2.27%	0.736
Technical problem on WH structure	18.18%	8.08 %	10.61%	0.09*

*, ** and *** denote significance at 10%, 5% and 1% respectively.
The values in the parenthesis are the standard errors
Source (Authors survey, 2014).

Factors affecting water banking participation and its impacts on food security

The farm households in Ethiopia are highly rain fed dependent though they have the potential of irrigation access from different water bank structures. Drought was one of the prevalence natural phenomena in Ethiopia. In some areas of the region, though they have access to water they did not use it efficiently throughout the year. This highly observed during the second round irrigation. Thus, it was important to investigate why farm households did not use the actual irrigation potential and participation on irrigation during dry season. As indicated on table 5 of the logit estimation model, distance to local market, lack all weather roads, absence and distance to water for irrigation, and the size of cultivated land holding has negatively affected participation in water banks. Family size, education of the household head, off farm income and livestock holding were positively affected participation on water bank. Aman (2013) revealed that the size of land holding and dependency ratio has negatively and significantly affected the irrigation participation. The negative relationship between farms size

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and participation in irrigation scheme was also found (Gebrehawaria et al., 2009; Tewodros, 2010). The number of livestock also positively affected irrigation participation since irrigation increases the feed availability for livestock. As Berhanu et.al (2003) explained all the mixed crop–livestock systems, irrigation can increase livestock feed supply through increased crop residues of food–feed crops, thus relieve the pressure on grazing lands and improving livestock productivity.

Family size and level of education were positively affecting the irrigation participation. The labor intensive nature of the irrigation scheme need the farm households to have a large family size and if the household have small farm size they might not have enough labor and time to involve on irrigation. These results were in line with the findings of (Haile, 2008; Shimelis, 2009). The distance to infrastructures and institutions also reduce the participation on water banking since their produce may not reach the market due to high transport cost and lack of information.

Table 5: Logit regression estimation of PSM

Variables	Coefficient.	Variables	Coefficient
Male household head	.365(.658)		
Age of household head	.022(.026)		
Year of schooling	.027(.104)*		
Family size	.238(.144)**		
Cul.farm size in tsimad	-.038(.207)		
Off farm participation	-1.52(.91)		
Crop pests disease	-1.061(.287) ***		
Distance to all season road	-.009(.017)	Livestock holding (TLU)	.119(.133)
Distance to water for irrigation	- .012(.013) **		
Off farm income	.01(.001) ***		
Distance to local market	-.015(.004) ***		
Distance to FTC	-.036(.015)*		

Farm income .004 (.00) ** Logistic regression
Number of obs = 132
LR chi^2 (15) = 38.41
Prob > chi^2 = 0.000
Log likelihood = -55.022654 Pseudo R^2 = 0.2587

*, ** and *** denote significance at 10%, 5% and 1% respectively.
The values in the parenthesis are the standard error
Source (Authors survey, 2014)

Water banks and farm households' food security

From the propensity score matching of Table 6, participation on water banking and irrigation practices has a positive and statistically significant effect on income. The average annual income for the water bank participant was about Birr 1703 and 1391 birr higher than the non-participants from the nearest neighbor and kernel estimators respectively.

The same finding was obtained by Haile (2007) and noted that there was a significant improvement in household income of shallow well users by 950-8000 Birr from grown vegetables on average. The per capita food consumption with ponds amounted to Birr 841.15 as compared to Birr 783.22 for those who do not have ponds or wells. Likewise, the average household food consumption expenditure for users of wells was found to be Birr 884.54 compared to Birr 783.22 for non users of pond or well water harvesting. The average annual per capita consumption expenditure of irrigation users was Birr 605.56 higher than non-users in eastern Harerge (Aman, 2013).

Higher income due to increased food productivity or from new employment opportunities created by irrigation schemes can lead to additional food purchases (vegetables, fruits, animal-source foods) and greater investments in health (medicines, healthcare, insecticide-treated nets) and education, which in the long term can also benefit women's empowerment(IFPRI, 2013). Generally as Berhane et al (2003) explained irrigation development may benefit the poor by raising labor productivity, promoting the production of high-value crops, and the generation of farm and non-farm employment opportunities, especially when increased production stimulates the local economy. Hence, we can conclude that water bank has a positive effect on improving food security[1] of the rural farm households and it is one of the necessary pathways towards economic growth and increasing sustainable productivities.

[1] Income, TLU and level of education are the proxy measure for food security in this study

Table 6: average treatment effect of the treated group (ATT) from the PSM model

Algorism	Treated	Controlled	ATT estimation of income	t- val.
Nearest neighbor Estimator	16198.76	14495.65	1703.118	3.06***
Kernel Estimator	16198.765	14807.613	1391.151	2.182**

*, ** and *** denote significance at 10%, 5% and 1% respectively.
Source (Authors survey, 2014)

Conclusion and recommendations

Improved access to agricultural water supply from different water banking strategies plays significant role in sustainable food security improvement of the small scale farm households. As a result, the government of Ethiopia has adopted the household level water harvesting ponds, shallow and deep well development largely the water banks as one strategy of the country's irrigation development in order to reduce poverty and enhance the rural economy in particular.

However, water banking practices were found to be constrained by resource related, bio-physical, institutional, technological/technical and socioeconomic factors. Agricultural input and output markets are among the major constraints of water banking. With this regard, market price fluctuation and rising prices of inputs like fertilizer and fuel were mentioned as bottlenecks for water banking. Resource related challenges such as shortage of water for irrigation, absence of well defined property right and enforcement lows and institution, small size of farm land for irrigation, lack of household labor have mentioned as significant challenges of participating on water banking.

Distance to local institution, infrastructures (market, all weather road and FTC) and the size of cultivated land holding negatively affected participation in water banking. Family size, education of the household head, off farm income and livestock holding positively affected participation on water banking.

Both the descriptive and econometric analyses confirm that irrigation/water banking has a positive impact on resource productivity and food security of the farm households. It was found that water banking is one pathway towards economic growth and increasing agricultural productivity by reducing seasonal migrations, creating employment opportunities and reducing risks of climate change for those who are relying on rain fed agriculture. Hence, policy and institutional interventions to enhance the impact of irrigation and creating water banking was very important. This could be done by enhancing the contribution of water banks and creating market for water and irrigation for household asset building through strengthening market access, promoting market oriented crops, and improving systems for providing extension and technical support to water banking strategies and arrangement. Therefore, the following recommendations are forwarded for effective water banking systems;

- Further attention should be given on rural infrastructure development; rural institution capacities building, awareness creation on market for irrigation water and producing market oriented products.
- For sustainable agricultural development of the country, water harvesting technologies have their contribution in the GTP of Ethiopia. They can be constructed and managed by the community with minor technical knowhow. The right choice of the water harvesting technique for the specific locality is required.
- Training in water management, general crop production and water marketing (efficient water allocations) is important for all water harvesting beneficiaries.
- Moreover, policy and institutional interventions to enhance the impact of irrigation and creating water banking is desired on water payments and assigning property rights.

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References

Abadie, A., (2003. Semi-parametric instrumental variable estimation of treatment response models. Journal of Econometrics, 113:231-263.

Aman, (2013). Impact analysis of mede telila small scale irrigation scheme on house poverty alleviation: case of gorogutu district in eastern haratghe oromia national regional state, Ethiopia. International Journal of

Development and Economic Sustainability, March 2013, pp.15-30. European Centre for Research Training and Development, UK (www.ea-journals.org)

B. Gebremedhin and D. Peden (2003). Policies and institutions to enhance the impact of irrigation developmentinmixedcrop-livestock systemsLength:pp.168-184 https://ilri.org/InfoServ/Webpub/fulldocs/.../IWMI/.../Berhanu.htm

Bhattarai, M., Barker, R. and Narayanamoorthy, N., (2007). Who Benefits from Irrigation Development in India? Implication of Irrigation Multipliers for Irrigation Financing, Irrigation and Drainage, 56: 207-225.

Braun, Joachim; Bouis, Howarth; Kumar, Shubh; and Pandya-Lorch, Rajul. (1992). Improving Food Security of the Poor: Concept, Policy, and Programs. Washington, D.C.: International Food Policy Research Institute

Bureau of Agriculture and Rural Development (BoARD),(2012). The Performance of Regional Growth and Transformation Plan: Annual Report, Tigray State Bureau of Agriculture and Rural Development, Mekelle, Ethiopia. http://www.tigraybopf.gov.et

Clifford, P., C. Landry and A. Larsen-Hayden (2004). Analysis of Water Banks in the Western States. Washington Department of Ecology. Publication number 04-11-011

DFID. (2002). Eliminating hunger: strategy for achieving the Millennium Development Goal on Hunger, DFID. London, May 2002

DLWC, Department of Land and Water Conservation (1998), Stressed Rivers Assessment Report: NSW State Summary, Department of Land and Water Conservation, Sydney

Elmahdi, A. (2006a), Water Banking –Land use Approach to Improve River Productivity and Environmental Cooperative Research Centre for Irrigation Futures (CSIRO) land and water, Adelaide Australia

Fafchamps, M., (2007). Program evaluation and treatment effects. Oxford University, Michelmas, UK.

Garrick, D. and K. Jacobs. (2006), Water Management on the Colorado River: From Surplus to Shortage in Five Years. South west Hydrology.

Gebrehawaria Gebregziabher, Regassa Namara and S. Holden, (2009). Poverty reduction with irrigation investment: An empirical study from Tigray, Ethiopia. Agricultural water management, 96(12): 1837-1843.

Haile, T., (2008). Impact of irrigation on poverty reduction in Northern Ethiopia. A PhD dissertation presented to the Department of Food Business and Development National University of Ireland, Cork, p. 200.

Idaho Water Resources Board (1999), History of the Water Supply Bank, http://www.idwr.idaho.gov (accessed Feb 2006).

Jacobsen JP (1999). Labor force participation. The Quart.Rev.Econ.Fin.39:597-610. http://dx.doi.org/10.1016/S1062-976 (99)00020-4

Kamara, A., G. Danso, S.A. Mahu, O. Cofie and P. Drechsel, (2004). Agricultural water investments and poverty impacts in West Africa: A review of tradable pumps with a focus on Ghana and Niger

Khan S. (2004), Integrating hydrology with environment, livelihood and policy issues – the Murrumbidgee Model, Special Volume on Hydrology for the Environment Life and Policy. Water Resources Development Vol. 20 (3): 415-429

L. Domenech H March, D Sauri , (2013). The Impact of Irrigation on Nutrition, Health, and Gender IFPRI Discussion Paper

Shimeles M., 2009. Impacts of productive safety net program on households assets protection. The case of Habru and Ambasel districts in Amhara Region, Ethiopia. MSc presented to the School of Graduate Studies (SGS) at Haramaya University, Ethiopia.

Stein and Sosina (2007). Land Valuation and Perceptions of Land Sale Prohibition in Ethiopia.

The Agricultural Water Solutions Project - Project: Agricultural Water ...awm-solutions.iwmi.org/the-ag-water-solutions-project.aspx