Agro Metrological and Cropping Pattern Analysis in North-Eastern Part of Amhara Region (A Case of North Shewa)

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Abstract

Recently environmental change mainly due to the climatic variation is a common phenomenon in Ethiopia. For example, the 1974, 1984, 1987, and 1995 drought caused famine and loss of agricultural production. This environmental change is mainly manifested in late onset and early offset of rainfall during the main season. Analysis of the existing and past farmers' cropping calendar, their response to the change, and comparison of the meteorological pattern to the cropping calendar were made in the north-eastern part of Amhara region. Household survey was conducted to collect required data on rainfall and cropping calendar pattern using questioner.

Farmers and those involved in the agricultural sector are more or less well aware of climate variability. The ability to understand, monitor, and predict this climate variability provides an opportunity to put historical experiences into perspective for making better decisions.

Farmers described that climate play a major role (42.16%) among the factors governing the timing of agricultural activities. Farmers characterized the current rainfall pattern by late onset and early offset (36.62 %). In all the study woredas, late onset of rainfall causing 10 to 40 days delay in the start of cropping calendar, similarly 10 to 40 days early offset were occurred in meher season. The 20 years mean monthly rainfall data of six stations also showed that the rainfall pattern became at decreasing rate. About 89.66 % of the farmers responded the occurrence of crop failure due to inadequate moisture in the season. From the total 97.67 % of the occurrence is due to the change in the onset and offset of rainfall. Responding to the change in rainfall pattern farmers were practicing in cultivating new varieties which one able to adapt the existing climatic change either because of their drought tolerance characteristics or short growing period.

The cropping calendars computed for the five stations using the soil-water balance criteria do not verify late onset and early offset of the rainfall. On average mid June and early to late November are the starting and ending dates of cropping calendar except Majetie station. Accordingly, the length of growing period becomes 130 to 155 days. The computed cropping calendar is approximately equal to the preference of the farmers indicated. However, the current starting and ending dates specified by the farmers are not ensured by the climatic data. This might be due to the fact that farmers have developed their own criteria on what soil moisture content, planting will be done for favorable crop germination.. This discrepancy calls for investigation of the criteria specific to crops and soils in order to check the climate pattern change in a better way. Otherwise, adjustments to the existing cropping calendar for the specific years and selective crops become relevant.

Keywords: Climatic pattern change, cropping calendar, onset and offset of rainfall, adjustment to cropping calendar

Introduction

Climate variability has a large impact on agricultural production, human health and the well-being of communities throughout the world. Therefore, research in this field has a high priority in many countries. Recently environmental change mainly due to the climatic variation is a common phenomenon in Ethiopia. For example, the 1974, 1984, 1987, and 1995 drought caused famine and agricultural losses. This environmental change is mainly manifested in late onset and early offset of rainfall during the main season and in most cases total failure of the *belg* season. In the past, the North-eastern part of the Amhara Region was more dependable on both main and short cropping seasons (*meher and belg*, respectively). However, in the past few decades rain fed agriculture, particularly *belg* rain, has failed to provide the minimum food requirement for the increasing population of these areas. As a result, drought affected *woredas* in the north-eastern part of the region in particular increased.

On the other hand, the long-term analysis of rainfall amount shows very little difference except few years (1974, 1984, 1987, and 1995). This implies the fact that the rainfall amount is not the main problem but its pattern. Although there is clear and recurrent rainfall pattern change, the cropping calendar still remains unmodified, except some adaptation efforts at household level. Some farmers are also questioning their cropping calendar and sometimes demanding to get assistance for reliable cropping calendar. Therefore, in order to adjust the cropping calendar in relation to the climatic change, a modest pattern analysis of the long-term meteorological variables and the existing and past cropping pattern is highly required.

Research results on climatic pattern analysis so far focused mainly on rainfall and temperature at the major meteorological stations in the country. In addition, such works didn't include analysis of the existing farmers cropping calendar or the response to the change. Therefore, the intention of the study was to fill this gap by including survey on the cropping calendar and explore its adjustment made for the change.

The study aimed to analyze the past and current pattern of agro meteorological elements and cropping activities in North-eastern parts of the region, North Shewa case. The study also compared meteorological pattern to the current cropping calendar followed by farmers. By knowing these patterns it will enable us to design an adjustment of the cropping activities based on the climatic pattern.

Materials and methods

Long-term meteorological data (1985-2004) at Alem Ketema, Enewari, Debre Birhan, Shola Gebeya, Mehal Meda, and Majetie meteorological stations were gathered from National Metreological Service Agency (NMSA). Graphical rainfall pattern analyses for the starting and ending dates were made for rainfall. The starting and ending dates of cropping calendar were computed using Instat v2.09 software. Using FAO water holding capacity map, low soil-water holding capacity range was taken for this purpose. Starting and ending dates were determined if soil-water balance $\geq$ 60 mm and $\leq$ 0.5 mm water holding capacity of the soil. A household survey technique on growing season pattern, calendar, and crop type were conducted in 13 *woredas*. These are Ankober, Antsokia Gemeza, Basona Werana, Efratana Gidem, Ensarona Wayu, Gera Keya, Hagre Mariam, Kewet, Lalo Mama, Merhabetie, Mida Weremo, Moretena Jiru, and Tarmaber. The selection process of respondents involved random sampling based on the selected *kebeles* available in each *woreda*. Eighty eight respondents were involved. The data collected was by face-to-face interview during the dry seasons of 2002-2004. The questions asked related to issues such as past and current starting and ending of rainfall seasons, preference starting and ending dates of rainfall, major crops grown and their cropping calendar, list of crops or varieties abandoned and those replacing them/newly cultivated, factors that govern timing of agricultural activities and growing period, and cope up strategies for the failure. The findings explore the knowledge of farmers on climate variability, rainfall characteristics, past and current seasonal variations and cope up strategies on the shift of crop type or crop varieties. The study further elaborates on cropping activities, the significance of seasonal shift and verifies the survey result by the rainfall and evaporation data. Water balance, starting, and ending dates of the cropping calendar for limited metreological stations were done to verify the survey data.

Results and discussion

In the survey areas the sample analysis showed that crop cultivation is dominantly dependent on rain fed agriculture (75.86 %) with less dependent on supplemental irrigation (16.38 %) as well as full irrigation (7.76 %). The cropping practice is generally single cropping (61.83 %) with seasonal crop rotation practice. In some of the cases (19.08 %), double cropping was possible using the main rain season and short rainy season or irrigation. Some of the farming communities (18.32 %) are also practicing intercropping.

Knowledge and experience of farmers on climate variability

Farmers and those involved in the agricultural sector are well aware of climate variability. The ability to understand, monitor, and predict this climate variability provides an opportunity to put historical experiences into perspective and to evaluate alternative management strategies for making improved decisions to take advantage of good years and whilst minimizing the losses during the poor years

One issue is the use of seasonal forecasts for predicting when events will happen, such as the date of onset of the wet season. Timing of when events occur is of great importance in agriculture. Break of season rains often causes failure of activities in agricultural communities, such as planting of crops. Crop cultivation management is generally based on the amount and pattern of rainfall. The extent to which water is available in a season is usually considered by farmers when deciding on cropping pattern. Farmers usually take the rainfall months into account. Besides the rainfall, farmers take market price of the product in deciding the cropping pattern. In some cases, the knowledge of farmers about rainfall and climate phenomena in general is so limited that they do not know how to optimize the rainfall use in each season for the benefit of their crop production (Huda, et al, 1991; Huda, 1994; Pollock, et al, 2001). However, to some extent they have adequate knowledge on weather forecasts based on historical experiences. They usually determined weather forecast based on the moist and warm air coming from oceans and its direction.

Factors determining timing of agricultural activities and growing period

In the survey areas, farmers described that climate play a major role among the factors governing the timing of agricultural activities (42.16 %) followed by availability of oxen (41.67 %) for land preparation immediately after start of rainy season. Labor is another factor contributed 13.24 % in determining the time of agricultural activities. Soil factors related to available moisture for crop production attributed for the length of the growing period. In this respect quick drying of the soil, water logging, and/or water holding capacity of the soil determined the growing period with respective contribution of 49.51 %, 29.13 %, and 19.42 %. This signifies that the availability of water either in the form of rainfall or irrigation water affect the cropping calendar.

Rainfall characteristics

As it was described by the farmers the rainfall is characterized by late onset and early offset (36.62 %) as well as inadequate in its amount (36.62 %) especially during the short rainy season. In some cases high amount of rainfall (26.76 %) at a time during the main rainy season has occurred. However, the rainfall data in the nearby metrological stations indicates that the amount was not a problem instead it was its pattern. The long-term monthly rainfall data showed that the rainfall pattern became at decreasing rate. In order to ensure the occurrence of late onset and early offset of rainfall, graphical observation of rainfall for each month at different years were made. For instance, in Debre Birhan the short rainy season became reduced after early 1990's compared to the mid 1980's. High fluctuations were observed in June at this station. In September, it was reduced in the period between 1995 and 1999. At Mehal Meda the rainfall during meher starting period was less from 1992 to 1995 and 1998 to 2002. Its offset was earlier after 1995 onwards. Data at Alem Ketema indicates rainfall decreased after early 1990's in the *belg* season, and the offset of rainfall was early after 1995, of course with some exceptional years. The starting date of rainfall in Enewari was earlier after 1987 except 1993 and 2001. Where as, in September it was the same after 1999 onwards.

Table 1: Current reduction of growing season in days relative to previous rainfall pattern and farmers' preference LGP for each *Woreda*

Woreda	Meher growing season			Belg growing season		
	Onset of rainfall late by	Offset of rainfall earlier by	Preference LGP	Onset of rainfall late by	Offset of rainfall earlier by	Preference LGP
Ankober	25-30 days	10-30 days	90	20-30 days	10-40 days	122
Antsokia Gemza	25-30 days	10-30 days	120	Offset	Offset	91
Basona Werana	20 days	10-30 days	141	Offset	Offset	97
Eferatana Gidim	10 days	20-30 days	121	30 days	30 days	84
Ensarona Wayu	30-40 days	20 days	118	Offset	Offset	78
Gera Keya	20-30 days	30 days	120	Offset	Offset	78
Hagre Mariam	10-20 days	30 days	107	Offset	Offset	88
Kewet	20-30 days	No shift	111	No shift	10-20 days	76
Lalo Mama	20 days	20-30 days	120	Offset	Offset	78
Merhabetie	20 days	20-30 days	105	30 days	30 days	66
Mida Oromo	10-20 days	20-30 days	106	Offset	Offset	68
Moretena Jiru	25-30 days	20-40 days	118	Offset	Offset	74
Tarma Ber	30 days	10-20 days	97	Offset	Offset	113

Twenty years weather data analysis for five to six stations showed that there was high variation in the starting of rainfall between specific years. But, the average starting dates of rainfall are approximately similar to the current rainfall pattern explained by farmers. Climatic pattern change in terms of onset and offset of rainfall has occurred only for specific years. Therefore, more or less the pattern of monthly rainfall data ensured the results obtained in the survey (Table 1). As a result, crop failure due to moisture stress occurred. About 89.66 % of the farmers responded the occurrence of crop failure due to inadequate moisture in the season because of 97.67 % change in the onset and offset of rainfall.

Table 2: Crops/varieties grown before the change in rainfall pattern and crops substituting them in each study *Woreda*

Woreda	Crops/Varieties grown before	Crops/varieties substituting the previous ones
Ankober	Sorghum (*Wogerie*), Maize (*Genbotie*), Barely (*Nech Mawgie*)	Sorghum (*Maycho, Cherekit*), Maize (*Bunegn*), Barely (*Tikur mawgie*)
Antsokia Gemza	Maize (Bursa), Sorghum (Afeso, Magna)	Sorghum (*Waye, Ayferie, Tigrie, Maycho, Cherekit*)
Basona Werana	Wheat (irrigated) Barley (irrigated)	Faba bean Lentil (irrigated)
Eferatana Gidim	Maize (*China, Bursa*) Wheat (*Tikur*) Sorghum (*Afeso*), Teff (*Magna*) Sorghum (*Amrieta*)	Maize (*Fetan, Chercherie*) Wheat (*Nech*) Sorghum (*Merhabatie, Melka, Mashen*), Teff (*Gemeza, Bunegn, Agay*) Sorghum (*Betin*)
Gera Keya	Barley (*Mawgie*), Wheat (*Shemet, Gojamie*)	Barley (*Nech*) Wheat (ET-13)
Hagere Mariam	Wheat (*Kenyia, Azazie*), Barely (*Qokima mawgie*)	Wheat (Isral, ET-13), Barley (*Nech gebes, Feres gama, Gedim, Molatie*)
Kewet	Sorghum (*Becha*)	Sorghum (*Maycho, Cherekit*)
Merhabetie	Sorghum (*Kondil, Amtut, Gultie, Tikurieta*), Teff (*Goradie, Wegedie*), Maize (*Abesha Bekelo, Ginbotie*), Wheat (*Ofiye*), Green Pepper	Sorghum (*Waye, Ayferie, Tigrie, Abaso*), Teff (*Guradie, Wegedie, Nech teff*), Maize (*Bono*) Wheat (*Kirtie, Nech Sindie*), Garlic,
Mida Oromo	Sorghum (*Ayferie*)	Sorghum (*Abaso*)
Moretena Jiru	Sorghum (*Nech Magna*)	Sorghum (*Key Magna*)

Strategic interventions

In response to the rainfall characteristics explained above, farmers tried to explore copping strategies or interventions when there is crop failure due to late rainfall. Among the strategies: shifting the sowing dates, cultivate crops that are able to grow on residual moisture, cultivate using irrigation are some to be mentioned. When there were failures of these options, they made ready the land for next season cultivation. The strategies were different from season to season. During *meher* cropping season, farmers tried to cope up the occurrence of late rain onset through planting on residual moisture (49.46 %), preparing the land for next season cultivation (32.26 %) and in some cases supporting with irrigation (5.38 %). In the short rainy season, *belg*, the copping strategies were mainly leaving the land for the next season cultivation (77.19 %), cultivate with the support of irrigation (12.28 %) and planting crops which have short growing period (10.53 %). Moreover farmers changed their crop types and the varieties they were adapted in the previous climatic condition. Crop varieties which are resistance to moisture deficit and are suitable to the short rainy season became newly cultivated and adopted to the current climatic condition (Table 2). When the problem became worst the farmers sold their livestock in order to avoid food insecurity.

Analysis of climatic pattern and cropping calendar

In order to see the shift in crop cultivation in rain fed agriculture due to the change in rainfall pattern, farmers were asked the starting and ending dates of the rainy season in the past and current times. Farmers were also asked their preference for the start and ending dates of the season for their cropping activities. Accordingly, comparisons were made among the past, current as well as farmers' preference starting and ending dates. Table 1 indicates the number of days by which the current rainfall pattern has changed compared to the previous one. In all *woredas* there was late onset of rainfall ranging from 10 to 40 days. Similarly 10 to 40 days early offset were occurred in meher season. During the belg season, there has been total offset of rainfall except in Ankober, Merhabetie, Efrata and Kewet *Woredas.* Farmers indicated the preference length of growing period during which major crops able to grow with out moisture stress (Table 1).

The cropping calendars computed for the five stations (Table 3) using the soil-water balance criteria mentioned above do not verify late onset and early offset of the rainfall. On average, mid June and early to late November are the starting and ending dates of cropping calendar except Majetie station. Implies the length of growing period become 130 to 155 days. The computed cropping calendar is approximately equal to the preference of the farmers indicated. However, the current starting and ending dates specified by the farmers are not ensured by the climatic data. This might be due to the fact that farmers' have developed their own criteria on what soil moisture planting will be done for favorable crop germination.. This discrepancy calls for investigation of the criteria specific to crops and soils in order to check the climate pattern change in a better way. Otherwise, adjustments to the existing cropping calendar for the specific years and selective crops become relevant.

Table 3: Cropping calendar determined from rainfall and evaporation data of the weather stations

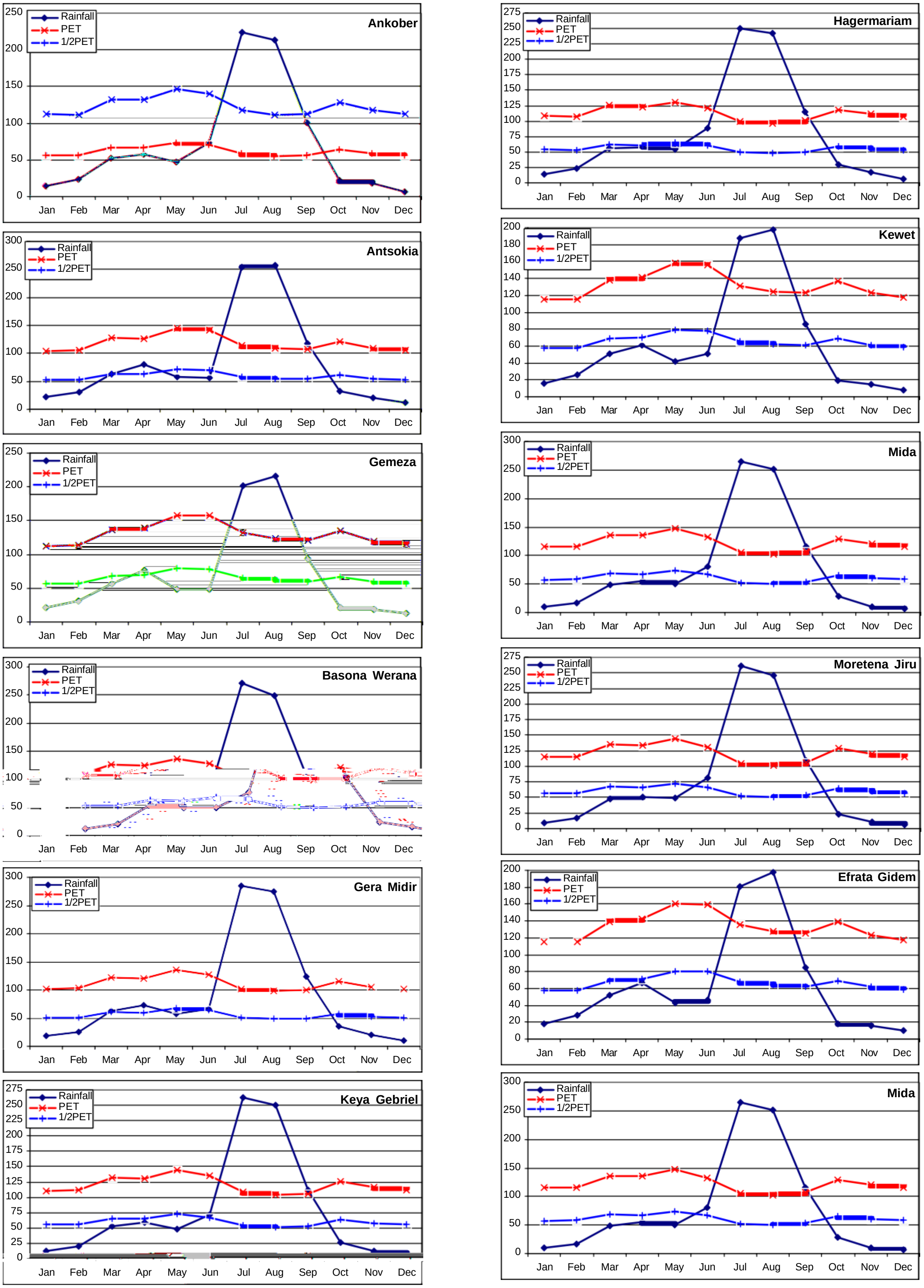
Station	**# years**	**Days when soil-water balance**		**LGP**
		≥ 60mm, Starting	**≤0.5mm, Ending**	
Debre Birhan	20	June 17±14.9 days	Nov 17±24 days	152.5±32
Alem Ketema	18	June 17±11.6 days	Nov 4±18 days	140±25
Mehal Meda	18	June 19±13.8 days	Nov 23±19.5 days	156±25
Shola Gebeya	19	June 16±16.4 days	Nov 14±23 days	150.5±32
Majetie	14	June 27±27.5 days	Nov 5±12.6 days	131±35

References

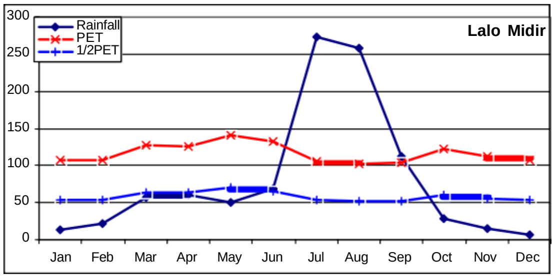
Huda, A.K.S. and Packham R.G. (eds), 2004. Using seasonal climate forecasting in agriculture: a participatory decision -making approach. ACIAR Technical Reports No. 59, 52 p.

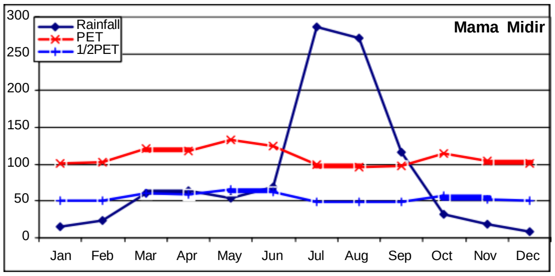
Huda, A.K.S., Packham R.G., Clewett, J.F., and George, D.A., 2004. Introduction and overview. In: Huda, A.K.S. and Packham R.G. (eds). Using seasonal climate forecasting in agriculture: a participatory decision-making approach. ACIAR Technical Reports No. 59, 52 p.

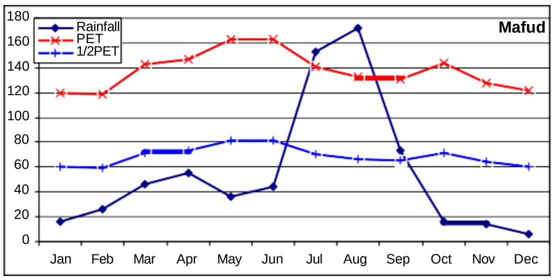
Appendix Figure 1: Mean monthly rainfall pattern and the relation with PET in the past years

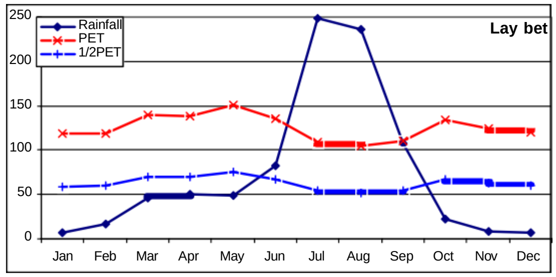


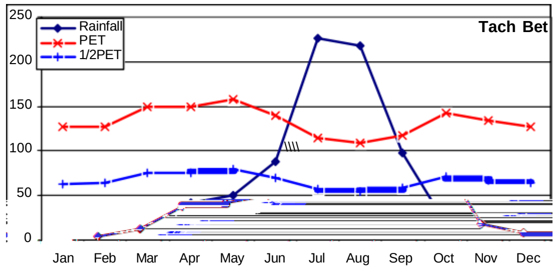
Appendix Figure 1: (contd.)











Appendix Table 1: Rainfall starting and ending dates and the length of growing period based on the rainfall and evaporation data of the weather stations

	Debre Birhan			Mehal Meda			Alem Ketema			Enewari			Shola Gebeya			Majetie		
Year	**Start**	**End**	**LGP**	**Start**	**End**	**LGP**	**Start**	**End**	**LGP**	**Start**	**End**	**LGP**	**Start**	**End**	**LGP**	**Start**	**End**	**LGP**
1985	2-Jul	24-Dec	175	3-Jul	16-Oct	105	1-Jul	8-Nov	130				19-Jun	27-Oct	130	8-Jun	27-Oct	141
1986	1-Jun	17-Nov	169	2-Jun	23-Nov	174	20-Jun	23-Oct	125				2-Jun	23-Oct	143	25-Jul	26-Oct	93
1987	5-Jul	*	*	4-Jul	*	*	5-Jul	14-Oct	101				13-Jul	15-Nov	125			
1988	2-Jun	24-Nov	175	2-Jun	13-Nov	164	6-Jul	3-Oct	89				5-Aug	6-Oct	62	14-Aug	14-Oct	61
1989	8-Jun	2-Dec	177	8-Jun	*	*	7-Jun	24-Nov	170				5-Jun	12-Nov	160	8-Jul	23-Nov	138
1990	1-Jul	16-Nov	138										1-Jun	29-Oct	150	1-Aug	4-Nov	95
1991	21-Jun	18-Nov	150										20-Jun	2-Dec	165	5-Jun	3-Nov	151
1992	15-Jul	18-Oct	95	29-Jun	12-Dec	166	29-Jun	30-Nov	154				7-Jun	31-Oct	146	10-Jun	29-Oct	141
1993	5-Jun	*	*	4-Jul	1-Dec	150	3-Jun	21-Nov	171				19-Jun	26-Nov	160	2-Jun	19-Nov	170
1994	5-Jun	19-Oct	136	25-Jun	15-Dec	173	20-Jun	23-Oct	125									
1995	1-Jun	*	*	1-Jun	*	*	1-Jun	25-Oct	146				2-Jun	17-Nov	168			
1996	5-Jun	20-Oct	137	4-Jun	4-Nov	153	4-Jun	23-Oct	141				4-Jun	30-Oct	148			
1997	1-Jun	30-Dec	212	1-Jun	*	*	2-Jun	8-Dec	189				2-Jun	26-Dec	207			
1998	25-Jun	21-Nov	149	25-Jun	27-Nov	155	21-Jun	13-Oct	114				24-Jun	22-Dec	181			
1999	21-Jun	2-Dec	164	2-Jun	31-Dec	212	24-Jun	18-Nov	147	6-Jul	1-Oct	87	2-Jun	17-Dec	198			
2000	24-Jun	*	*	28-Jun	6-Nov	131	19-Jun	5-Nov	139	7-Jul	2-Oct	87	24-Jun	10-Dec	169	1-Jun	30-Nov	182
2001	26-Jun	*	*	26-Jun	25-Nov	152	10-Jun	23-Oct	135	9-Jun	4-Nov	148	11-Jun	*	*	12-Jun	7-Nov	148
2002	4-Jun	18-Nov	167	10-Jul	22-Nov	135	4-Jun	8-Nov	157	24-Jul	1-Oct	69	14-Jun	1-Nov	140	17-Jun	3-Nov	139
2003	2-Jun	*	*	21-Jun	*	*	21-Jun	11-Nov	143	16-Jun	28-Oct	134	21-Jun	30-Oct	131	2-Aug	2-Nov	92
2004	11-Jul	10-Oct	91	18-Jun	19-Nov	154	19-Jun	13-Nov	147	22-Jun	1-Oct	101	19-Jun	28-Oct	131	3-Jun	31-Oct	150
Mean	17-Jun	17-Nov	152.50	19-Jun	23-Nov	155.69	17-Jun	4-Nov	140.17	29-Jun	11-Oct	104.33	16-Jun	14-Nov	150.78	27-Jun	5-Nov	130.85
Stdev	14.92	24.34	32.34	13.83	19.54	25.24	11.62	17.99	24.57	16.47	15.78	30.49	16.35	23.19	31.88	27.49	12.60	34.94

Appendix Table 2. Current, previous and preference rainfall starting and ending dates for rain fed agriculture at different *Woredas*

Woreda	**Previous meher starting date**	**Previous meher ending date**	**Previous belg starting date**	**Previous belg ending date**	**Current meher starting date**	**Current meher ending date**	**Current belg starting date**	**Current belg ending date**	**Preference meher starting date**	**Preference meher ending date**	**Preference belg starting date**	**Preference belg ending date**
Ankober	Early June to early July	Mid September to early October	Early November to mid January	Late January to early May	Early to mid July	Mid August to late September	Early December to early February	Early March to late April	Late June to early July	Mid September to early October	Early January to early February	Late March to late May
Antsokia Gemza	Early June to early July	Mid September to early October	Early December to early February	Late March to late April	Early to mid July	Early September	Offset	Offset	Mid June to early July	Mid to late October	Early January to early March	Mid March to late April
Basona Werana	Early to mid June	Mid September to early October	Early to mid February (none)	Late March to late April	Late June to early July	Early September	Offset	Offset	Early to mid June	Mid October to mid November	Early February	Late April
Efratana Gidim	Mid June to early July	Mid September to early October	Early December to early February	Late February to late April	Late June to mid July	Late August to early September	Early January to early February	Late February to late March	Early June to early July	Mid to late October	Early January	Late March to late April
Ensarona Wayu	Early to mid June	Early to late September	Late January to early March	Late April to early June	Mid July	Mid August to early September	Offset	Offset	Late May to mid June	Late September to early October	Early to mid February	Late March to late May
Gera Keya	Early to mid June	Mid to late September	Mid January to mid February	Late March to late April	Late June to mid July	Mid to late August	Offset	Offset	Early to mid June	Late August to mid September	Early to mid February	Mid March to late April
Hager mariam	Late June	Late September	Late January to early February	Late April to late May	Early to mid July	Late August to late September	Offset	Offset	Mid June	Late September to early October	Late January/ early February	Late April to early May
Kewet	Late June to early July	Late August to late September	Early February	Late March to late April	Mid July to early August	Late August to early October	Early February	Early April	Early July	Mid to late September	Early February	Late March to late April
Lalo Mama	Late May to early July	Mid September to mid October	Late January to early March	Late March to early May	Mid June to early July	Late/mid August to mid September	Offset	Offset	Mid May to mid June	Mid September to mid October	Early February to early March	Late March to late May
Merha betie	Early to late June	Mid September to early October	Early February to early March	Late April to late May	Late June to mid July	Late August to mid September	Early March	Late April	Early to mid June	Mid September to early October	Early March	Mid April to early May
Mida Oromo	Mid to late June	Mid September to early October	Early March to early April	Late April to mid May	Late June to mid July	Late August to early September	Early March (offset)	Late April (Offset)	Early to mid June	Mid September to early October	Early March to early April	Late April to late May
Moretena Jiru	Early to late June	Late September	Early March	Early to late May	Early to mid July	Mid August to early September	Offset	Offset	Mid June to early July	Mid September	Early March to early April	Mid to late May
Tarmaber	Mid June	Mid to late September	Mid December to mid January	Mid February to mid April	Mid June to mid July	Late August to mid September	Late December to mid January (none)	Early February to early March (none)	mid to late June	Late September to early October	Early to mid January	Late April

Appendix 3. Cropping calendar of the major crops in the irrigated and rain fed production systems

Woreda	**Type of agriculture**	**Crop type**	**Land preparation**					**Sowing date**	**Weeding time**	**Harvesting**
			1st	**2nd**	**3rd**	**4th**	**5th**			
Tarmaber	Irrigated	Onion	Nov.	Dec.	Jan.			Late Jan-Feb	Feb - Mar	May – June
		Pepper	Jan	Feb	Mar			April	Late April - May	October
	Rain fed *Meher*	Barley	Jan	Feb	Mar	April	May-June	July	Sept	Oct
		Teff	Jan	Feb	Mar	April	May-June	Late July	Aug	Early Oct-Nov
		Maize	Jan	Feb	Mar	April	May-June	Late June-July	Late July-Aug	Oct-Nov
		Wheat	Jan	Feb	Mar	April	May-June	July	Aug	Oct-Dec
		Lentil	No	Land	prepared			July	Not needed	Late Sept-Nov
		Chickpea	July	Aug				Late Aug-Early Sept	Sept	Nov-Dec
		Haricot bean	No	Land	prepared			July	Not needed	Oct
		Faba bean	No	Land	prepared			June-July	July-Aug	Oct-Nov
		Sorghum bicolor	Jan	Feb-Mar				April	May-June	Nov-Dec/Jan
		Mung bean	No	land	prepared			Feb	Not needed	May-June
		Sesame	No	land	prepared			April	June	Oct
	Rain fed *Belg*	Barley	Oct	Nov				Dec-Jan	Feb-Mar	May-June
		Teff	Oct	Nov	Dec	Jan		Feb-Mar	April	Late May-June
		Maize	Dec					Jan-Feb	Feb-Mar	June
		Wheat	Oct	Nov				Jan-Feb	Feb-Mar	May-June
		Lentil	No	Land	prepared			Feb	Not needed	May-June
		Chickpea	Nov	Jan				Feb-Mar	Mar-May	May-June
		Haricot bean	No	Land	prepared			Jan-Feb	Not needed	Early June
Lalo Mama	Rain fed *Meher*	Barley	April	May-June				June	July-Sept	Nov
		Wheat	Mar-Apr	Apr-May	June			July	Aug-Sept	Late Dec-Jan
		Faba bean	No Land preparation					June	Aug - Sept	Late Nov-Dec
		Garlic	April	May-June				June-July	Aug-Sept	Nov-Dec
		Potato	April	June				June	Aug	Oct - Nov
		Field pea	Mar	April				June	Not needed	Dec
		Flux	Apr-May					June	Not needed	Dec - Jan
	Rain fed *Amegn*	Barley						Sept	Not needed	March
		Wheat						Sept	Not needed	March
Moret-Jiru (Kolla)	Irrigated	Pepper	Sept	Oct	Nov	Dec		Jan	After 10 day/4X	Mid May-June
		Tomato	Oct					Oct	After 30 day/3X	Late Jan
		Maize	Jan	Feb				Jan-Feb	Mar-Apr	May-June
		Teff	Jan-Feb					Feb	Mar	April-May
		Onion	Sept	Oct				Oct-Nov	After 20 day/6X	Mar-Apr
	Rain fed *Meher*	Teff	Jan-Apr	May	June			July	Late Aug-Sept	Oct-Dec
		Sorghum	Jan	Mar				June-Early July	July-Aug	Nov-Dec
		Sesame	Jan	May	June			July	Late Aug-Sept	Nov-Dec
		Noug	No land	Preparatio				June-early July	Not needed	Late Oct-Nov
		Onion	May-Jun					July	Mid July-Aug	Oct

Appendix Table 4 (contd.)

	Rain fed *Belg*	Sorghum	Jan	Mar				Mar-Apr	June, Aug	Dec
	Irrigated	Pepper	Sept	(Oct.)				Oct	Oct-Nov	Feb-April
		Tomato	sept					Oct	Oct-Nov	Mar
		Maize	Sept					Sept-Oct	Oct-Dec	Feb-Mar
		Teff	Mar					Early Mar	Mar-apr	June
		Onion	Sept					Oct	Nov	Apr
		Barley	Mar	Apr-May				June-July	July-Aug	Oct-Dec
		Teff	Mar	July				July	Late Aug	Early Oct-Nov
		Chikpea	Aug					Sept	Oct	Jan
		Wheat	Mar	Apr-May				July	Mid Aug	Nov-Jan

Gera Keya Rain fed *Meher*