Astronomy and Indigenous Knowledge in the Wolaita Community (Ethiopia): Implications of Education and Agriculture

Temesgen Bazaw Injero

A Thesis Submitted To the Department of Applied Physics
School of Applied Natural Science

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Applied Physics (Astrophysics)

Office of Graduate Studies
Adama Science and Technology University

June 2022
Adama, Ethiopia

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DECLARATION

I hereby declare that this Master Thesis entitled **“Astronomy and Indigenous Knowledge in the Wolaita Community (Ethiopia): Implications of Education and Agriculture”** is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation

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RECOMMENDATION OF ADVISORS

We, the advisors of this thesis, hereby certify that we have read the revised version of the thesis entitled **"Astronomy and Indigenous Knowledge in the Wolaita Community (Ethiopia): Implications of Education and Agriculture"** prepared under my guidance by Temesgen Bazaw submitted in partial fulfillment of the requirements for the degree of Masters of Science in Astrophysics. Therefore, we recommend the submission of revised version of the thesis to the department following the applicable procedures.

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APPROVAL SHEET

We, the advisors of the thesis entitled **"Astronomy and Indigenous Knowledge in the Wolaita Community (Ethiopia): Implications of Education and Agriculture"** and developed by Temesgen Bazaw, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Temesgen Bazaw have read and evaluated the thesis entitled **"Astronomy and Indigenous Knowledge in the Wolaita Community (Ethiopia): Implications of Education and Agriculture"** and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Astrophysics.

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Final approval and acceptance of the thesis is contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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School Dean	Signature	Date
Office of Postgraduate Studies, Dean	Signature	Date

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LIST OF ACRONYMS AND ABBREVIATIONS

ADAs	Agricultural Officers and Development Agents
BCE	Before the Common Era
EOTC	Ethiopian Orthodox Tewahedo Church
FGD	Focus Group Discussion.
MOARD	Ministry of Agriculture and Rural Development
PAR	Photosynthetically active radiation
SNNPR	Southern Nations, Nationalities, and Peoples' Region
UNESCO	United Nations Educational, Scientific and Cultural Organization

GLOSSARY

Local terms	**Definitions**
Agina	*Month*
Baazaoy zoo'iyes	*red sky in the morning*
Badhdheesaa wodiyaa	*planting time (planting seasons)*
Ceggennaa	*phenomenon occurs moon phases that bad for agricultural activities*
Xeero ceggennaa	*phenomenon occurs new moon phases*
Goobana ceggennaa	*phenomenon occurs full moon phases*
Gojiliyaa	*group of stars six in number*
Gifaataa	*The name for Wolaita New Year celebration*

Signs of the zodiac

Aries	♈
Aquarius	♒
Cancer	♋
Capricorn	♑
Gemini	♊
Leo	♌
Libra	♎
Pisces	♓
Scorpio	♏
Sagittarius	♐
Taurus	♉
Virgo	♍

Moon Phases

New moon	●
First quarter	☽
Full moon	○
Last quarter	☾

ABSTRACT

The aim of study was to analyze the astronomy and indigenous knowledge of the Wolaita community regarding the use of astronomical rhythms and elements in agricultural activities and its progressive implications in the education of the Wolaita community. The special focus of the study was five woreda, that are Boloso Sore woreda, Boloso Bonbe, Kindo Didaye woreda, Kindo Koysha woreda, and Damote Gale woreda, which are selected trough random sampling procedure. A total of 25 households were overall sample size for the study. Types of plant seedlings were selected randomly for planting and transplanting. And also the trees to be felled were identified and authenticated. The study used both qualitative and quantitative research methods, including interviews, surveys, experiment and focus group discussions, to gather data from members of the Wolaita community. The data was analyzed qualitatively and examined in parallel with Newton's law of gravity. The study found that the cultural astronomers of Wolaita have been using various astronomical rhythms and elements, such as stars, planets, comets, and the moon, for centuries to guide their agricultural practices, determine the timing of significant activities, and mating intervals. Specifically, the study found that the cultural astronomers of Wolaita observe three specific stars - Toorojiyo, Bakkaliyo, and Gojilliyaa - to determine seasonal cycles, timing of daylight and darkness, and navigation. Additionally, the study found that the cultural astronomers of Wolaita observe moon phases to determine seasonal cycles for agricultural activities and for women to keep track of their menses and fertility cycles. They predict the month's future using the moon. The study verified the effect of ceggennaa during planting and transplanting seedlings, as well as felling trees, in different phases of the moon. The study found that the reasons why plant seedlings dry up and wither, and why felled trees are attacked by weevils and diseases during ceggennaa may be light it reflects from the Sun and its gravitational influence. The study also found that cultural astronomy of Wolaita plays a significant role in shaping the socio-economic, educational, and cultural landscape of the community. However, this valuable indigenous knowledge is on the verge of extinction and cannot be integrated into the education system, except for its use in farmers and sky readers, as well as to celebrate "Gifaataa" or the "New Year" celebration of Wolaita. The study called upon responsible bodies to notice the role of Wolaita cultural astronomy and the threat it has faced, and act in the way they rescue it from disappearance.

Key words: Agriculture, Astronomical rhythms and elements, Cultural astronomy, Indigenous knowledge.

CHAPTER ONE

INTRODUCTION

1.1 Background and Justification

Astronomy denotes an extensive study of astronomical incidents occurring beyond our earth's inhabitants (Rosenberg *et al.*, 2014). Human beings have an intense curiosity towards things that happen in the sky, leading to numerous civilizations' comprehensive research and interpretation. Ancient people observed celestial phenomena to predict crop yields or avert potential doom from external celestial happenings (Robbins, 2000). Consequently, cultural astronomy has emerged as a field that examines how different societies perceived and made meaning out of celestial events (C. Ruggles, 2015).

The study of cultural astronomy examines how astronomical events have influenced human cultures throughout history. This interdisciplinary field incorporates multiple fields such as astronomy, archaeology, anthropology history and sociology to investigate its many facets (Whaanga *et al.*, 2016). Cultural astronomy looks at how different societies have applied their understanding of the cosmos in practical ways including navigation strategies, precise time-keeping methods and agriculturally related activities such as those associated with seasonal planting schedules (Malville, 2008). Ancients commendably demonstrated an exceptional interest in celestial bodies; they built intricate observatories to track stars positioning thereby enhancing their perception of existence while establishing calendric information which enabled management of daily affairs.

One area of particular interest within cultural astronomy is the study of astronomical rhythms in agricultural activities. Astronomical rhythms have been an important part of agricultural activities for thousands of years. This relationship dates back to ancient civilizations, such as the Mayans and the Egyptians, who tracked celestial cycles in order to determine when to plant crops, harvest fields, and breed livestock (Aveni, 2001). Similarly, the Inca civilization of Peru used their knowledge of the stars to develop an agricultural calendar that marked the seasons and guided planting and harvesting. The Native American Hopi tribe of Arizona has a complex oral tradition that describes their relationship with the sun and stars, which informs their agricultural practices (Williamson, 1987). Similarly, many indigenous communities recognize the solstices and equinoxes as important times for planting and harvesting, based on the position of the sun in the sky (Neugebauer, 2013).

These practices of agricultural activities based on astronomical rhythms have been verified through experiments conducted by various researchers. Schultz (1935) conducted over 300 experiments to evaluate the effectiveness of agricultural practices based on lunar rhythms, including the moon's phase and constellation within the zodiac. Similarly, Stanislaw (2006) tested the Mesoamericans' practice of planting during the waxing and waning moon phases. Jaeger (1936) followed astrological indications from Paracelsus and Albertus von Magnus and published his findings, which were only partially verified by subsequent tests (Spiess, 2000). Overall, the experimental results suggest that seeding according to astronomical rhythms is most appropriate for seed research, planting, seed growing, and the cultivation of medicinal herbs, which aim to produce high-quality products (Sivasankar *et al*., 2021).

In addition to the practical applications of astronomical knowledge in agriculture, cultural astronomy has influenced religious and spiritual beliefs by shaping myths and legends surrounding celestial events. For instance, Ancient Greek Mythology believed that the stars were the homes of the gods, while Hinduism believed that the position of the stars and planets impacted human affairs (Pannekoek, 1989). The Mayans believed that the movements of the planets and stars predicted the future, and Aboriginal Australians believed that the stars were the spirits of their ancestors (Thompson, 1974). Christianity also has a connection to astronomy, as the Star of Bethlehem guided the wise men to the birthplace of Jesus (Charles, 1906; Selin, 2012). These are just a few examples of how cultural astronomy has played a role in shaping religious and spiritual beliefs across different cultures.

Like ancient people everywhere, Ethiopians have long been fascinated by the sky and have struggled to make sense of it. They preserved an amazing heritage in terms of calendars that are still in use in different parts of the country (Charles, 1906; Neugebauer, 1964). For example, Borana Astronomy (Night Observation, Moon Exploration, Borana Calendars, and the corresponding implications and applications to everyday life) (Bassi, 1988a; Doyle, 1986; C. L. Ruggles, 2015), Ethiopian Orthodox church Astronomy (astronomical rhythm, daylight and dark nighttime navigation, legends, myth, and star lore) (Brown, 1972; Neugebauer, 1964), Shoa Astronomy (Moon Exploration, myth, and star lore's), Sidama

Astronomy (Moon Exploration, Sidama Calendars), Mursi Astronomy (Mursi Calendar, mythological, and star folklore) (C. L. Ruggles, 2015), and etc. are among identified ones. However, there are many signatures and Celestial Objects in Ethiopia which are not yet exposed.

Influenced heavily by cultural astronomy, the Wolaita community residing in southwestern Ethiopia has shaped their way of life accordingly. Their reputation for being deeply ingrained in both agriculture and education indicates an elevated level of importance placed on these values (Buta, 2016). They have a rich cultural heritage that is deeply rooted in agriculture and education (Buta, 2016; Dunnavant, 2017; Olango *et al.*, 2014). The community has a unique way of life that is closely tied to the natural environment, including the moon, the stars and other celestial bodies. The Wolaita people have a long history of observing the sky and using astronomical knowledge to guide their agricultural practices and daily activities (Abaro, 2015).

The astronomical rhythms and Celestial Objects have played a critical role in the lives of the Wolaita people in southwestern Ethiopia. The traditional lunar-solar calendar has served as a guide for agricultural practices, religious celebrations, and social customs for hundreds of years (Salimpour *et al.*, 2022). The recognition of women's expertise in astronomy and the potential educational value of traditional knowledge systems highlight the progressive and forward-thinking nature of Wolaita astronomy. As we continue to grapple with issues of climate change and environmental sustainability, the lessons of Wolaita astronomy could provide valuable insights into how we can live in harmony with the natural world.

In spite of its high relevance to the Wolaita people's lives, there is a noticeable dearth of research on how astronomy affects education, agriculture, or progress in their culture. To address this gap effectively requires exploring just how astronomical rhythms and elements influence these realities for them. With such knowledge gains new insights into how their entire way of living has come to be shaped via such means is obtainable through our investigation. Therefore, this thesis aims to investigate the historical and cultural significance of astronomy in the Wolaita community, as well as the educational, agricultural, and other practical implications of astronomical rhythms and elements.

1.2 Statement of the Problem

How does astronomy integrate with culture? How do we know what we know about the astronomical activities of the ancient and current cultures of the Wolaita? Do astronomical rhythms really influence climate and agricultural activities? If so, how much and how? How does the knowledge of Wolaita culture predict and forecast future seasonal changes using celestial objects in the sky? Does the astronomical knowledge of Wolaita culture impact educational progress? These were the basic questions that we answered in this study. Popular beliefs on the effects of astronomical rhythms on weather, farming, and life in general probably date back to when ancient civilizations followed astronomical rhythms.

Serious sky-observing cultures, such as the Maya, went beyond simply observing the sky and developed calendars based on the reliable motions of celestial bodies like Venus. Like ancient people everywhere, Ethiopians have long been fascinated by the sky and have struggled to make sense of it. Ethiopia's cultural astronomy is replete with mythic figures, cosmology and cosmogony, divination methods that utilize observations of celestial bodies, planting in astronomical rhythms, and many other sky-related beliefs and traditions. The agricultural and livestock practices of Ethiopians have been based on this astronomical knowledge, which has been crucial to their survival(Charles, 1906; Mekonnen, 2013).

Despite the importance of this astronomical knowledge, the heritage of its impact on agriculture, forecasting the future, and seasonal changes, as well as its role in sustaining livestock lives, has not been investigated in many provinces of Ethiopia, particularly in the Wolaita community. Furthermore, the culture of astronomical observation has not been recorded in written form, and there have been few studies conducted in the area. This lack of research has made it difficult to fully appreciate the value of Ethiopia's cultural astronomy and to develop strategies for preserving and promoting it. As a result, the culture of Woliata astronomy is believed to have faced several problems, and it could not be passed from one generation to another effectively. Among the problems, the following are considered the main ones:

The modern farmer and gardener did not practice the indigenous astronomical knowledge of agricultural activity instead they use costly artificial technologies with little consideration of their environmental or human health impacts. Such technologies are far removed from the ancestral knowledge of past civilizations and current indigenous communities. Consequently, the level of climate in these areas has resulted in economic instability which has affected the communities negatively as they are subject to natural hazards like drought and floods.

No study has been made on the culture of Woliata's astronomy point of view. Hence, it is not documented and the advancement of technology. And people are not fully aware that the culture of Woliata astronomy is on the verge of extinction because such culture has not been studied yet. So, this study meant to solve the problem and thereby recommend ways of tackling it.

1.3 Objectives of Study

1.3.1 General Objective

The general objective of the study was to analyze the astronomy and indigenous knowledge of the Wolaita community regarding the use of astronomical rhythms and elements in agricultural activities and its progressive implications in the education of the Wolaita community by taking Boloso Sore woreda, Boloso Bonbe, Kindo Didaye woreda, Kindo Koysha woreda, and Damote Gale woreda as the focus area.

1.3.2 Specific Objectives

The specific objectives of the study were based on the astronomy, education, agriculture, and cultures of the Wolaita community. The objectives were:

- ✓ To observe their agricultural activities related to celestial objects and the ability to forecast the climate change by astronomical rhythm and natural disaster management.
- ✓ To examine the indigenous knowledge of the Wolaita community regarding their use of astronomical rhythms in agricultural activities.
- ✓ To describe their daylight and dark nighttime navigation and the prediction of seasonal changes using celestial objects.
- ✓ To assess the progress of education in understanding the cultural astronomy.
- ✓ To relate modern astronomy prediction by mitigating the cultural astronomy problems.
- ✓ To mitigate the problems of cultural astronomy seek possible substitution with modern astronomy prediction.

1.4 Scope of Study

The study aimed to explore the educational, agricultural, and progressive implications of astronomical rhythms and Celestial Objects in the Wolaita community in southwestern Ethiopia. The study focused on the Wolaita community's traditional knowledge and practices related to astronomical events, such as the phases of the moon, changes in seasons, and weather patterns. The researchers examined the indigenous knowledge of the Wolaita community regarding astronomical rhythms and their use in agricultural activities, including planting seedlings and cutting trees. The study also examined the potential for using astronomical knowledge to promote progressive development in the community. Modern methods of astronomy were introduced to extend the cultural disaster management system.

The research was conducted using a mixed-methods approach, including qualitative and quantitative data collection methods. The qualitative data was collected through interviews, focus group discussions, and observations, while the quantitative data was collected through surveys and questionnaires. The study involved a sample of Wolaita community members, including farmers, educators, and community leaders. The acquired data was recorded in audio and put in written documents to pass from one generation to another effectively the culture of Wolaita astronomy.

1.5 Significance of Study

First, we must accept that every culture has a science, that is, a way of defining, controlling, and predicting events in the natural world. Then we must accept that every science is legitimate in terms of the culture from which it grew. And also astronomy was integrated into the culture. In the case of the culture of astronomy, the study of the sky is arguably the first science. And astronomy was essential for regulating the calendar and eventually for navigating and mapmaking (Haynes *et al*., 2000). The study of astronomy, cultural astronomy, and astronomical rhythms in agricultural activities has important implications for our understanding of the natural world and our place in the universe. It highlights the importance of interdisciplinary research and the need to integrate different fields of study to gain a deeper understanding of complex phenomena. Hence, the culture of Wolaita astronomy is part of science and the study will be a great deal of significance in the end;

- ✓ The struggle and mitigate today's weather change by astronomical rhythm and natural disaster management knowledge of the Wolaita community.
- ✓ That enhances sustainable agricultural management; mitigates the influence of astronomical rhythms in agriculture and paradigm for a new scientific.
- ✓ That impacts the educational progress mitigating the problems of cultural astronomy.
- ✓ That will open the eyes of scholars and bold out Wolaita community astronomy especially, the link between astronomical rhythms and agriculture.
- ✓ Serve as a mirror to witness the people what problems the astronomy of Wolaita is facing nowadays.
- ✓ It will help all stakeholders to understand the challenge posed by the astronomy, agriculture, and culture of Wolaita and to recommend ways of conserving them.

The findings of the study will be contributed to the understanding of the role of astronomy in the educational and agricultural practices of the Wolaita community. The study also provided insights into the potential for using astronomical knowledge to promote progressive development in the community. The study had implications for policy and practice in the areas of education, agriculture, and community development. Furthermore, it lays the ground for further research to be made particularly on the astronomy, agriculture, and culture of Wolaita community by different researchers or elite groups.

1.6 Limitation of Study

During the course of studying this topic, the researcher faced the following limitations that caused the bottle neck for this study.

- ➢ Among these, lack of written materials in the area of “cultural astronomy of Wolaita” in-line with educational, agricultural, and other practical implications of astronomical rhythms and elements agricultural activities and the naked eye observation and prediction of celestial objects perspective is the major one. This has caused a problem that forced the use of other review literature that do not directly relate to cultural astronomy of Wolaita, but which discuss astronomy across western Cultures in Ancient Times. It is obvious that if there were written materials on cultural astronomy of Wolaita, analyzing it as a communication from the scholars’ point of view would be a lot more favorable and credible.

- Inadequate logistics and facilities since it requires inter-local travel affected the study a lot because every step in the study demanded a big finance due to the less accessibility of elders who could give information. This condition made the data collecting and analysis a lot difficult. However, if logistics and facilities had been available, it would have been possible to integrate the limited resources and other conditions to access further areas to make the study quality.

- The limitation of time for conducting experiments for further test during the winter season and other remaining months was due to the University's confined schedule. As a result, the study may not have fully captured the range of seasonal variations that could have potentially affected the research outcomes. Additionally, the limited time available for data collection may have resulted in a smaller sample size, which could have affected the statistical power of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Astronomy and Culture

Astronomy is the scientific study of celestial objects such as stars, planets, comets, and galaxies, as well as phenomena that originate outside the Earth's atmosphere. It is one of the oldest sciences, dating back to ancient civilizations such as the Babylonians, Egyptians, and Greeks. The history of astronomy can be traced back to prehistoric times when early humans used the stars to navigate and keep track of time. However, the formal study of astronomy began in ancient Mesopotamia around 4000 BCE, where the Babylonians developed a sophisticated system of celestial observations and recorded them on clay tablets (Neugebauer, 1969). The ancient Egyptians also had a keen interest in astronomy, using it to develop their calendar and align their pyramids with the stars (Belmonte *et al.*, 2023).

The Greeks further developed the field of astronomy, with notable figures such as Aristotle, Hipparchus, and Ptolemy making significant contributions to the study of celestial objects. Aristotle, for example, believed that the Earth was at the center of the universe and that the stars were fixed in the sky (Pannekoek, 1989). Hipparchus, on the other hand, developed a system of cataloging stars and measuring their positions. Ptolemy, meanwhile, developed a geocentric model of the solar system that was widely accepted for centuries (Kunitzsch, 2017). During the Islamic Golden Age, astronomers such as Al-Khwarizmi, Al-Farghani, and Al-Battani made significant contributions to the field, including the development of trigonometry and the use of astrolabes for celestial navigation (Saliba, 2007).

The birth of astronomy in different world society class is different. For example, Astronomy in the early Middle Ages of Western Europe can also be called Romano medieval astronomy which is started in the period from 4th to the 6th centuries (McCluskey, 2017). The birth of astronomy in Indonesia was in nineteenth and early twentieth centuries on Java as a branch of natural science during World War II of Japanese occupations (Hidayat, 2000). The birth of astronomy in Indian subcontinent was begin during the period of 3rd millennium BCE in Indus Valley Civilization (Pingree, 1978). The sophisticated knowledge of Europe in mathematics and astronomy was born in 1990 BC (Atkinson, 1974).

In the Renaissance period, astronomers such as Nicolaus Copernicus, Johannes Kepler, and Galileo Galilei revolutionized the field with their discoveries and observations. Copernicus, for example, proposed a heliocentric model of the solar system in which the Sun was at the center, while Kepler developed laws of planetary motion that explained how planets move around the Sun (Gingerich, 1993). Galileo, meanwhile, used telescopes to observe celestial objects and made numerous discoveries, including the four largest moons of Jupiter (Winkler *et al*., 1992).

After the revolution the modern astronomy was born in the 19th century. Currently, as our understanding of the world progresses, we find ourselves and our view of the world even more entwined with the celestial objects and stars. The modern astronomical discovery based on the basic elements that we find in stars and other celestial objects, and the gas and dust around them, are the same elements that make up our bodies has further deepened the connection between us and the universe. This linkage touches our lives, and the awe it inspires is perhaps the reason that the beautiful images astronomy provides us with are so popular in today's culture (Rosenberg *et al*., 2013). This shows astronomy is integrated into the culture and the culture around the globe develops a certain capability in it. This discipline is called Cultural astronomy.

2.2 Cultural Astronomy

Cultural Astronomy is the study of humans and their relationship to the sky. The Connection is practical things of human activities such as timekeeping, weather prediction, seasonal calendars for agricultural activities, and navigation, etc. And also it is connected to artistic inspiration, metaphysical beliefs, and as well as human relationships regarding the scientific studies of astronomy, astrophysics, space sciences, atmospheric science, and planetary science. Included is the study of the history and evolution of all of these and more within regions, cultures, and sub-groups. Because of this connections it is possible to say that the sky determines the way in which human populations defined themselves and their surrounding world (Stanisław Iwaniszewski, 2011). An official definition of cultural astronomy was put forth by Nicholas Campion (1997): Cultural astronomy is the study of the use of astronomical knowledge, beliefs, or theories to inspire, inform, or influence social forms and ideologies, or any aspect of human behavior (Jarita Holbrook, 2016).

Cultural astronomy focuses on the many ways in which people and cultures interact with celestial bodies and integrate them into their view of the world. It looks at how astronomical knowledge and beliefs can inspire and influence social structures, ideologies, and behavior. It encompasses the modern disciplines of ethnoastronomy – a branch of astronomy concerned with the astronomical beliefs and practices of specific cultures – and archaeoastronomy, which focuses more on the astronomically aligned objects, monuments, megaliths, and ceremonial constructions of civilizations past (Liritzis *et al.*, 2022b). Within this broader formulation, the discipline of cultural astronomy has roots going back hundreds of years, though the term itself was first used in the late 1980s (Baity *et al*., 1973). These are similar concepts but basically differ in how people look at the data. In ethnoastronomy, data is collected by ethnologists by talking to people and watching what they do. Archaeoastronomers generally work from the material remains of people.

It is also related to historical astronomy (analyzing historical astronomical data), the history of astronomy (understanding and study and evolution of the discipline of astronomy over the course of human knowledge), and the history of astrology (investigating relationships between astrology and astronomy) (Carlson *et al*., 1999). Astronomy across cultures in ancient times is different in different culture in their way of observing, predicting and navigating to sustain their livestock's. As example, in Ancient Babylonian, Assyrian, Egyptian, and Chinese astronomers knew the approximate length of the year while in Africa they use sky for practical purposes.

The Egyptians of 3000 years ago, for example, adopted a calendar based on a 365-day year. They kept careful track of the rising time of the bright star Sirius in the predawn sky, which has a yearly cycle that corresponded with the flooding of the Nile River (DeYoung, 2000). The Chinese also had a working calendar; they determined the length of the year at about the same time as the Egyptians. They recorded comets, bright meteors, and dark spots on the Sun. We still use some of these records in studying stars that exploded a long time ago. The Mayan culture in Mexico and Central America developed a sophisticated calendar based on the planet Venus, and they made astronomical observations from sites dedicated to this purpose a thousand years ago (Thompson, 1974). The Polynesians learned to navigate by the stars over hundreds of kilometers of open ocean a skill that enabled them to colonize new islands far away from where they began.

In Britain, before the widespread use of writing, ancient people used stones to keep track of the motions of the Sun and Moon. We still find some of the great stone circles they built for this purpose, dating from as far back as 2800 BCE (Seidelmann, 2020). This shows the people all over the world have different culture in the night sky observation and struggled to make sense of it. However, the beside difference astronomic study was a common activity across the globe, we have a vast literature on European sites such as Stonehenge but much more limited scholarly work on the rest of the world. In part, this is a problem of data; history, after all, is not what happened, but what gets recorded and told. But we also face a barrier to a more complete understanding: our single-minded view of the way to do science, and indeed our definition of science. This has restricted our ability to understand other astronomies and other ways of doing science like Africa (Selin, 2012).

Like ancient people everywhere, Africans wondered at the sky and struggled to make sense of it. African cultural astronomy is rich with mythic figures, cosmology and cosmogony, divination methods that utilize observations of celestial bodies, and many other sky-related beliefs and traditions. African cultural astronomy is entwined with religious beliefs and practices, agriculture, artistic efforts, folklore, and social hierarchies. The sky is also utilized for practical purposes in Africa (J. O. Urama *et al*., 2009). Observations are useful for navigating at night; timekeeping and establishing an accurate calendar; and noting menses and fertility cycles.

In Africa, there are hundreds of ethnic cosmogonies and mythologies that need to be studied more systematically. For non-science majors, it can show the commonality of the scientific method (observations - hypothesis - more observations, etc.) even when the concluding theory is religious in nature. For science majors, it can show that scientific reasoning is not something new to Africa and not divorced from African life and culture (J. Urama, 2021). The cosmogony and mythologies of many ethnic nationalities of Africa show that astronomy, among the sciences, has the deepest cultural roots. One of the strategies for trying the African cultural astronomy project 49 to bridge the gap between traditional and modern astronomy in Africa, is to reinterpret myths using the scientific lens of modern astronomy. For example, the description of creation told by followers of

Cabbala (a form of Jewish mysticism), has been interpreted along modern cosmological views (Baki, 2006).

Astronomy is neither foreign nor colonial in Africa – its origin is within the continent. Most African societies have developed indigenous astronomical knowledge largely for understanding and predicting seasonal weather changes. These communities depend mostly on rain-fed agriculture for subsistence farming, so they use their knowledge of the day and night sky to forecast rainfall and to predict periodic phenomena such as floods and droughts (Mapfumo *et al*., 2016). For example, ethnic communities in East Africa such as Luos of Kenya and Tanzania use their knowledge to interpret astronomical phenomena for solving their local problems. These traditional methods rely on the interaction of plants and animals with the terrestrial environment. Other ethnic communities such as Timbuktu in Mali in central Africa, Masai of East Africa, Basotho Bushmen, Sotho, Tswana and Venda, Xhosa use Pleiades and brighten stars to indicate the beginning of cultivating season, the coming of the season of rains and daylight and the dark night time navigation and the prediction of seasonal changes (JC Holbrook, 2020).

The study of cultural astronomy highlights the deep relationship between celestial objects, culture, and human life on earth. The influence of astronomy on culture provides a deeper understanding of the beliefs, values, and practices of various cultures worldwide, from ancient civilizations to contemporary society. The impact of astronomy in everyday life cannot be overlooked, as it plays a significant role in shaping human beliefs, achievements, and future aspirations. However, the field of cultural astronomy as we know it today began to take shape in the 20th century, with the work of scholars such as E.C. Krupp, Anthony Aveni, and Clive Ruggles.
In the 16th century, the Spanish conquest of the Americas leads to the destruction of many indigenous astronomical traditions in the Americas (Aveni, 2001). In the 19th century, scholars such as Sir James Frazer and J.G. Frazer begin to study the relationship between astronomy and mythology in different cultures. In the 20th century, scholars such as E.C. Krupp, Anthony Aveni, and Clive Ruggles begin to develop the field of cultural astronomy as a distinct area of study(C. Ruggles, 1999). In the 1970s, the term "ethnoastronomy" is coined by Anthony Aveni to describe the study of how different cultures understand and use astronomical phenomena (Aveni, 1989). In the 1990s, the International Society for Archaeoastronomy and Astronomy in Culture is founded to promote the study of cultural astronomy.

2.3. Cultural Astronomy in Ethiopia

Ethiopian cultural astronomy is a practice that has been used for centuries to guide agriculture practices. Farmers in Ethiopia have used the positioning of celestial objects, such as the moon and stars, to determine planting and harvesting times, which have led to higher yields and better quality produce. The Ethiopians also have a tradition of star lore’s and legends. Stars and other celestial bodies can be given creative names that reflect their general physical and specific characteristics. Upon agreement, these can be used to name celestial objects and special physical characteristics of stars.

In the distant past, the knowledge of astronomy and mathematics was abundant in Ethiopia. Books such as the mysteries of heaven and earth, and the book of Enoch, and Abu Shaker are devoted to this knowledge (Made *et al.*, 2014). There is a large body of indigenous knowledge of astronomy in Ethiopia that people use to keep time. In addition, some exploration can be made on Ethiopian diverse cultures and languages and how such rich cultures can be instrumental in shaping the future astronomy and space science curricula and documentation.

Such documentations are preserved in different manner in their ethnic and linguistic groups. For instance they preserve an amazing heritage in terms of calendars that are still in use in different parts of the country. The literature about Ethiopia and its constituents is filled with rich documents about religion, science, mathematics, astronomy, and cosmology in terms of Mursi Astronomy, Borana Astronomy, Konso Astronomy, Sidama Astronomy, and many more. In addition, Ethiopian Christian and Islamic traditions demonstrate formal knowledge of the fields of science.

Despite the positive impacts of Ethiopian cultural astronomy, there is still much more to learn and understand about the practice. Many practices have been passed down orally, and the exact details of certain traditions may vary from region to region. Therefore, there is a need to preserve this knowledge and document it for future generations to continue its meaningful impact on the country's agriculture and culture.

2.3.1. Main Ethiopian Calendar

Ethiopia has a rich history of cultural astronomy, which dates back to ancient times. For the Ethiopians, the stars were an essential part of religious worship, and their movements were believed to hold powerful spiritual significance. The Ethiopian Orthodox Tewahedo

Church (EOTC), which has been practiced in the country since the fourth century AD, played an influential role in the development of the culture's astronomy practices. The signs and movements of celestial objects, such as the moon and stars, were used to calculate religious events, such as the timing of the holy days and religious observances.

The Ethiopian calendar constructed on the EOTC. The calendar is based on astronomic events, including the annual movements of stars and the solstice and equinox points. The EOTC calendar is different from the Gregorian calendar used by most of the world and is unique to the EOTC and the Ethiopian people. They use a solar calendar which has 365 days divided into 12 months of 30 days, and Pagume, the 13th month. It holds 5 days for a normal year, but this number becomes 6 every leap year and 7 every 600 years (Brown, 1972). It bases its calendar on dates declared in the Holy Bible. The EOTC has its own unique customs and traditions, which have been influenced by Judaism. The Ethiopic Book of Enoch which is written in Ge’ez and which the EOTC has comprised in its canon provides the commentary of what Enoch, the seventh generation from Adam, saw when Archangels took him to show him the entirety of the known Universe (Haile *et al*., 2006).

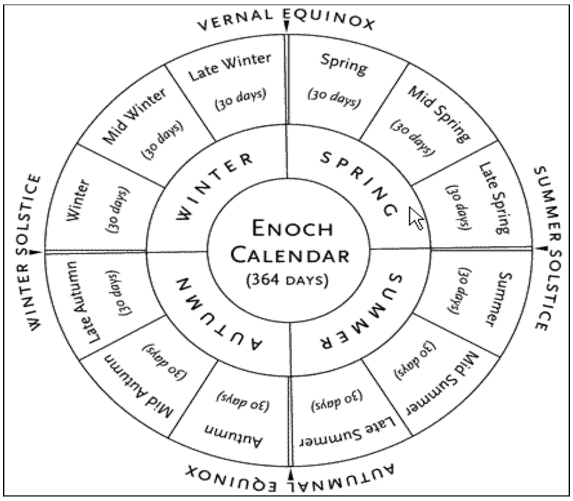

Figure.2.1: The right side is Ethiopian Astronomy/Zodiac (Haile *et al.*, 2006),
Figure.2.2: The left side is Enoch Calendar (Charles, 1906)

This is how Ethiopians started to calculate time, following the pace of Biblical history from Genesis up to the time of Jesus Christ. Some of the main events are as follows: Adam to the Great flood: 2256 years, Adam to Abraham: 3428 years, Adam to the exile of Babylon: 4918 years, Adam to Birth of Jesus Christ: 5500 years. This is the time God gave Adam to come to this World. The EOTC based its calendar (see the above figure) on these calculations.

2.3.2. Borana Cultural Astronomy and Calendar

The Borana people of southern Ethiopia and northern Kenya have a unique system of cultural astronomy that is closely tied to their agricultural practices and important cultural events such as weddings and festivals. Their living style is based on indigenous knowledge of the cosmos view where they have developed the Gada system as a whole general governing principle of both nature and social affairs (Doyle, 1986). The calendrical system they use within the Gada system is astronomical, a lunar-stellar system. The system is based on astronomical remarks of the moon in conjunction with eight or more particular stars (or star groups).There are twelve lunar synodic months in a year, but no weeks. Each month is identified with a unique astronomical observation by the Ayyantus who are the specialists in making such observations among the Oromo people (Legesse, 1973).

The New Year starts with the observation of the new moon in conjunction with Beta Trianguli (Legesse, 1963). The next month starts when the new moon is found in conjunction with the Pleiades, and so on until the first six months of the calendar are started by the astronomical observations of the new phase moon found in conjunction with six specific locations in the sky marked by the stars (Doyle, 1986). In this way the whole Oromo year is identified astronomically and when the new phase moon is finally seen again in conjunction with Beta Triangulum the next New Year will begin (Bassi, 1988b).

2.3.3. Sidama Lunar Calendar

The Sidama people live in the southern part of Ethiopia (Magane, 2015). They monitor their own lunar calendar system which is different from both the Ethiopian and Western (Gregorian) calendar system. Their calendar is based on investigative findings of the Ayyantto (Sidama astrologist). At nighttime, they get out of their houses to collect outside and observe the Moon's size, shape, color, change of position through time, and related situations of the solar system. Additionally, they also observe its spatial relation to other stars in terms of their relative positions, movements, and whether they appear separated or close to the moon and/or to each other. The Ayyantoo conduct their observations for at least six to ten days per month.

Base on this observation they announce the first day of the New Year, called Fichchee, will be announced when the Ayyantto sees a close approximation of the moon to five constellations of stars, known in the Sidama language as Buusa, with well-defined movements observed in relation to each other and to that of the moon. The people used this transition not only for the new year but also a time for new year people to marry, select would-be lovers, and the bride and circumcise groups to participate in the society and begin to live their life (Male, 2017). The Sidama calendar has 13 months in a year; each month of the year in the Sidama Calendar is equally divided into 28 days while the 12th month has 29 days. In addition to that, according to Male, 2017 there are four seasons in the Sidama two distinct seasons named `hawado` (wet season) and `Arro` (dry season) (Tekle, 2014). The history of the Sidama calendar and its relation to the overall socio-economic, political and cultural spheres of life of the Sidama people and related matters is such a rich and broad subject that cannot be exhausted in such a short description as this one.

2.3.4. Mursi Calendar

The Mursi people of Ethiopia are renowned for their unique culture and astronomy. They are a semi-nomadic tribe that lives in the Omo Valley, located in the south-western part of the country. The Mursi are known for their traditional beliefs and practices, which include a strong connection to the stars and the night sky. The Mursi people have a deep understanding of the night sky and its movements. They use the stars to tell time, predict the weather, and even to determine when it is time to move their herds. They also use the stars to navigate their way through the Omo Valley.

Mursi has a seasonal calendar based on the phase cycles of the moon. Every member of the group, including children, can relate the various seasonal events and activities associated with each month in Mursi community; for example, in month 8 the "big rains" fall. Each year (bergu) contains 13 months, starting with a named month, gamwe, followed by months numbered from 1 to 12 ("bergu 1" actually means "the bergu is 1 month old", so it is in fact the 2nd month) (C. L. Ruggles, 2014).

Intercalation to keep the calendar in step with the seasons is not accepted as an issue because, in practice, no Mursi ever seems certain what the current month actually is, though they may speak of "experts" and are generally aware of the prevailing views (e.g., "some say it's [month] five and some say it's six"). To an outsider, the Mursi calendar seems haphazard and imprecise; yet for the Mursi themselves, this "agreeing to disagree" produces a self-consistent system that is perfectly fit for purpose. Expertise on the calendar is specifically linked by the Mursi to the knowledge and skills necessary to divine future events by inspecting animal entrails (C. Ruggles *et al*., 1996) (Figure. 2.3). Such skills do not accord any special social status and are not acquired by formal training; they are often passed on from father to son.

Figure.2.3: Mursi diviners predicting future events using the entrails of a goat (After Ruggles and Turton 2005, Figure. 4. Courtesy of Ocarina Books and the Center for Archaeoastronomy)

One way to settle opinions about the current month is to “watch the sun”. They recognize the sun's two "houses" in which it rises for a period of time at the extremes of its sojourn along the horizon, around the time of the solstices. The sunrise position is, of course, directly linked to the time of the solar year, so that any one observation could in theory be used to eliminate all disagreement at a stroke. However, the sun is not seen as any more reliable a seasonal marker than any other, so such observations are not seen as definitive; in practice, they merely help to sway the balance of opinion (C. L. Ruggles, 2015).

The Mursi people also use the stars to tell stories. They use the stars to tell stories about their ancestors, their gods, and their culture. They also use the stars to tell stories about the natural world, such as the changing of the seasons and the movement of the animals. The Mursi people's traditional knowledge of astronomy is integral to their way of life and underscores their deep connection to the natural world. By drawing inspiration from the sky, the Mursi people have been able to navigate their environment, sustain their agriculture and livelihoods, and preserve their cultural heritage. The recognition and preservation of the Mursi cultural astronomy practices serve to remind us of the importance of traditional knowledge in promoting sustainable living and ensuring the preservation of valuable cultural heritage.

2.4. Astronomical Rhythm in Agriculture

The Moon and the Sun hold an important place in many mythologies and popular legends throughout the world. The Sun ruled our heart, blood circulation, and spine, while the Moon had an influence on growth, fertility, breasts, stomach, uterus, and menstrual flow. In fact, all the body fluids, such as the tides, were controlled by the lunar phases. This was the prevalent belief at that time since astrology was broadly accepted as the key to understanding the universe. Amazingly, these beliefs are still active, as shown by Phillips in his Encyclopedia of Plants in Myth, Legend, Magic, and Lore which includes more than 200 entries linking different plant species or genera with stars or natural elements (Phillips, 2012).

Planting by the astronomical rhythms is an ancient practice applied to pre-plan farm operations by taking advantage of the natural rhythms to support crop health and production. This is as much an old-time method highly encouraged by Rudolf Steiner1 as a part of biodynamic agriculture (Mayoral *et al*., 2020). However, the Current scientific experiments show that traditional moon lore play main role in agricultural until today in rural society. Even today the waxing or waning position of the moon is taken into account when cutting trees for lumber, for example. Lumber cut during periods of the waxing moon is believed to decay sooner and become more attacked by destructive insects. The validity of this statement was confirmed through experiments in Austria and Cuba by Jahn in 1982 and by Leon and Barrio in 1987. They showed how firs and pines, which were felled before the full moon, were attacked more frequently by the bark beetle (*Ipidae* spp., *Pityogenes*) than those trees cut before the new moon (Jovchelevich, 2021).

In tests with seeds and seedlings, it was frequently shown that plants seeded before the full moon brought higher yields and better quality than those seeded before the new moon. Schultz (1935) did more than three hundred series of experiments which, in addition to those evaluating the phases of the moon, also included the moon's constellation within the zodiac and other lunar rhythms. In 1936 Jaeger, who followed astrological indications given by Paracelsus and Albertus von Magnus, published the results of his investigations. Other authors, however, could only partly verify his findings in subsequent tests (Spiess, 2000). The experimental results indicate that the consideration and practical application of seeding according to lunar cycles seem most appropriate for seed research, seed growing, and the growing of medicinal herbs, all specialty areas which strive to achieve the highest quality in the final product (Sivasankar *et al*., 2021).

According to Santos G. (1992) Astronomical configurations in Amuesha' society are linked to agricultural activity. He thought that the existence of priests in the Amuesha' society mainly explained the richness of cosmology and astronomic as knowledge. The Amuesha recognize at least 29 celestial bodies apart from the sun and the moon. These include single stars and planets, star-to-star constellations, bright nebulae, and dark clouds. For the Amuesha, a star is not just a star: all of them were divinities or human essences of animals and material objects that people the earth in ancient eras. Consequently, he described of the 29 Amuesha constellations four have special cosmological and calendrical significance. The different positions of these constellations constitute the meaningful 'sky marks' which, together with other empirical phenomena, are closely watched by the Amuesha to determine the beginning and end of the seasons, the time for certain subsistence agricultural activities, and the performance of their ritual festivals (Santos Granero, 1992).

The idea that the moon affects the growth of plants is a widespread traditional belief related to the almost universal association of this luminary with the concepts of fertility. Stanislaw (2006) described the Mesoamerican agriculturalists believes the influence of moon on the growth of plants. He identified that the rules of symbolic logic by which the influence of the moon upon planting and harvesting in Mesoamerica was define. His survey of the anthropological data indicates that Mesoamericans usually emphasize the differences between the effects of the waxing and waning moon, but they also watch over the moments of the dark of the moon, first moon and full moon. Consequently, he described in most cases the Mesoamericans plant by the waxing (increasing) moon and harvest by the waning (decreasing) moon (Stanislaw Iwaniszewski, 2006).

This shows the history of the great civilizations of the past (such as the Egyptians, Babylonians, Greeks, Incas, Mesoamericans, and Aztecs) gave significance to astronomical rhythms, not only for agriculture but for all daily activities. Furthermore many societies metaphorically compare the cycles of crop growth to major events in a human history; so they easily transfer traditions linking the moon with human fertility to critical agricultural operations. Conventionally they consider that the best moments for planting and harvesting as well as for animal life and human conception are governed by the astronomical rhythms.

Consequently, for this indigenous knowledge many ethnological studies document the relationship between the farming practices of indigenous peoples and their knowledge of astronomical phenomena. However, in particular beliefs regarding the relationships between lunar phases and human and other organisms' behavior are as ancient as human cultural heritage but have hardly ever found any solid scientific support.

2.5. Tides and Orbital Dynamics of Moon

Tidal force is the gravitational force that is exerted by one object on another object, causing a deformation or distortion in the shape of the object. This force is most commonly associated with the gravitational pull of the moon and the sun on the Earth's oceans, which causes the tides to rise and fall. The tidal force is a result of the difference in gravitational attraction between two objects. The force is stronger on the side of the object that is closer to the other object, and weaker on the side that is farther away. This difference in force causes a deformation or distortion in the shape of the object, which can be seen in the tides of the Earth's oceans (Munk *et al*., 1998).

D. J. Webb, 1982, discussed the role of tidal forces in the evolution of the Earth-Moon system. He explained how the gravitational interaction between the Earth and the Moon has caused changes in the rotation rate of both bodies over time, leading to the synchronization of their rotations and the gradual recession of the Moon from the Earth. He also explored the impact of tidal forces on the Earth's oceans and the formation of tidal features such as tidal flats and estuaries (Webb, 1982).

The tidal force is not limited to the Earth's oceans, however. It can also be observed in other celestial bodies, such as moons and planets. For example, the tidal force of Jupiter's moon Io is so strong that it causes volcanic activity on the moon's surface (Tyler *et.al*, 2015). The tidal force equations describe the gravitational force exerted by one celestial body on another, which varies with distance and can cause tidal effects such as the rise and fall of ocean tides. The tidal force equations for two masses, m1 and m2, separated by a distance r, are:

Magnitude of tidal force: $$F_{tidal} = \left(\frac{GM_1M_2}{r^2}\right) \tag{2.1}$$

Direction of tidal force: The force is directed towards the center of mass of the two masses. Where, G is the gravitational constant. These equations show that tidal forces decrease rapidly with distance, becoming weaker as the distance between the two masses increases.

To better understand how tides are caused, one should view the relationship between the Earth and Moon as a system that is affected by the gravitational forces of the Sun and the Moon on the Earth. According to Newton's law, the force of gravitation decreases with distance, so the region of the Earth closest to the Moon experiences a greater gravitational pull, causing the oceans in that area to bulge toward the Moon. The bulge on the opposite side of the Earth is caused by a centrifugal force. The Earth's mass is much greater than the Moon's, so their common center of mass lies within the Earth's surface closest to the Moon (Williams *et al.*, 2016). Both the Earth and Moon revolve around this center of gravity, causing the centrifugal force to exceed the gravitational pull of the Moon on the side away from it, resulting in a bulge away from the Moon (Figure 2.4).

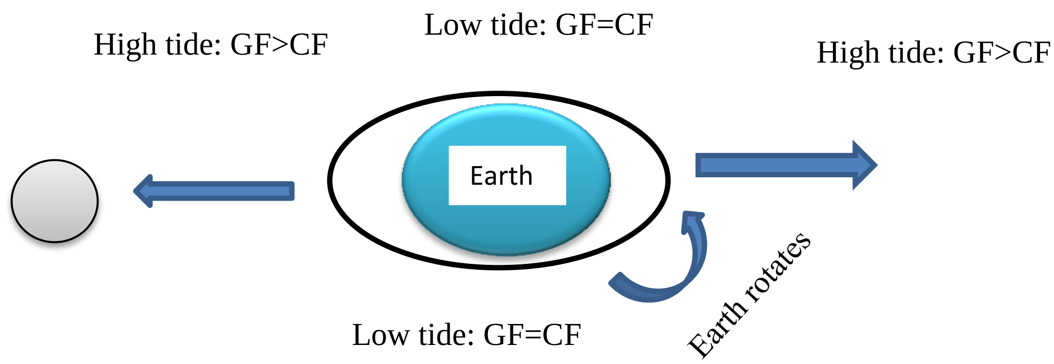

Figure.2.4. Diagram illustrating the Earth–Moon system and the influence of the gravitational force (GF) and centrifugal force (CF) on the two tidal bulges

The orbital dynamics of the Moon involve its motion around the Earth, which is mainly governed by the mutual gravitational attraction between the two bodies (De Leo *et al.*, 2022). Some of the key features of the Moon's orbit are:

1. **Eccentricity**: The Moon's orbit around the Earth is slightly elliptical, with an eccentricity of about 0.0549. This means that the distance between the Moon and the Earth varies over time, with the closest point (perigee) being about 363,104 km and the farthest point (apogee) being about 405,696 km.

2. **Inclination**: The Moon's orbit is inclined at an angle of about 5.14 degrees to the Earth's equator. This means that the Moon's apparent path across the sky (or ecliptic) is inclined to the path of the Sun by the same amount.
3. **Synchronous rotation**: The Moon rotates on its axis at the same rate that it orbits the Earth, so the same side of the Moon always faces the Earth. This is known as synchronous rotation, or tidal locking.
4. **Lunar phases**: The Moon's position relative to the Earth and the Sun results in the different phases of the Moon, from the new Moon to the full Moon and back again.

The moon's orbital dynamics also play a significant role in tides. The moon's distance from the Earth and its position relative to the Earth and sun affect the magnitude and timing of the tides. For example, when the moon is at its closest point (perigee) and is aligned with the sun and Earth (new or full moon), the tides are higher than average, known as spring tides. Conversely, when the moon is at its farthest point (apogee) and is at a right angle to the Earth and sun, the tides are lower than average, known as neap tides (Touma *et al.*, 1998).

2.6. Cultural Astronomy and Its Outcome on the Local Society

Indigenous peoples continue to use and pass on their ancient astronomical heritage through storytelling; wisdom originating from countless generations ago (Dalgleish, 2021). This support seeks to bring the perspective of cultural astronomy to the discussion of the links between astronomy and the social world. It is obvious that celestial observation had a deep and resounding impact on ancient cultures. It helped societies advance in many ways, from science and travel methods to agriculture and trade. Examples from various continents, time periods, and civilizations will be presented by area, beginning with the civilizations that flourished around Europe, then Africa, Asia, the Americas, and finally Oceania (Liritzis *et al.*, 2022a).

The knowledge of cultural astronomy can often be used as an easy way to start a gradual process of introducing a modern understanding of the universe. By bringing to the public the things we know about the universe and more importantly, how we know them, cultural technologies merged with scientific methods can spread knowledge of science and technology. Today the astronomical elements contained within monuments, sites and landscapes are regarded as valuable and important to our universal heritage (Marín *et al.*, 2010). Not only do they hold significance and meaning for traditional groups and for that communities, but also for the heritage of all peoples. It is also fundamental core of the measurement of time in relation to the daily cycle of work as well as the annual round of agricultural activities to indicate the planting season, serves as proof of the advanced thinking and observations of our ancestors.

On the other side the product of cultural astronomy is natural disaster management. Globally, there is increasing acknowledgement of the relevance of indigenous knowledge as an invaluable and underused knowledge reservoir, which presents developing countries, particularly Africa, with a powerful asset in environmental conservation and natural disaster management. Specifically, from time in memorial, natural disaster management in Africa has been deeply rooted in local communities which apply and use indigenous knowledge to master and monitor climate and other natural systems and establish early warning indicators for their own benefit and future generations (Kaya *et al*., 2016).

In Africa, local communities had well-developed cultural astronomy knowledge systems for environmental management and coping strategies, making them more resilient to environmental change. This knowledge had, and still has, a high degree of acceptability amongst the majority of populations in which it has been preserved. These communities can easily identify with this knowledge and it facilitates their understanding of certain modern scientific concepts for environmental management including disaster prevention, preparedness, response and mitigation (Koitsiwe, 2019). The indigenous knowledge is a precious national resource that can facilitate the process of disaster prevention, preparedness and response in cost effective, participatory and sustainable ways. Hence a blend of approaches and methods from science and technology and from traditional knowledge opens avenues towards better disaster prevention, preparedness, response and mitigation (Mapfumo *et al*., 2016).

Concerning development in education, cultural astronomy has very important contributions to do. According to Lopez, 2019, a true education should always be an intercultural education (López, 2019). The viewpoint of cultural astronomy is essential when thinking about the associations between professional academic astronomy and global society. It also contributes for researchers in cultural astronomy and in particular the methodological contribution of ethnoastronomy. As instance Western Academic Astronomy assumes certain base metaphors and proposes a possible repertoire of emotions and attitudes toward the sky.

The desire for the preservation of ancient, indigenous or modern systems of astronomical knowledge is justified by the wider public interest. These ideas are obvious for those who grew up socialized in them. Other human groups are profoundly opposed to their own way of experiencing and thinking about the sky (López, 2019). Whatever the Cultural astronomy is an interdisciplinary dedicated to the study of social facts. We can say that Cultural astronomy is a perspective that is not searching for fragments of "our" astronomy in distant cultures. We live in a socio-cultural-environmental reality. Our knowledge is a socio-cultural product (Bloor, 1998), including astronomy. Our world is a universe full of meanings, schemes of perception, and metaphors organized into Cosmo visions/worldviews and cosmologies, to which we are introduced by the other members of our society. The more important the sky is for a society, the more their power mechanisms will be involved in managing the links with it.

To conclude, cultural astronomy has had a significant impact on local societies, both in terms of religion education, and practical applications, such as navigation and agriculture. By promoting and preserving this knowledge, we can continue to celebrate the diversity and beauty of different cultures and promote education and economic growth in local communities.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Description of the Study Area

The study was conducted in the Wolaita zone. Wolaita zone is located in landscape diversity within Ethiopia's South Western Region. This location boasts different terrains ranging from highland plateaus down to low-lying valleys while covering roughly an area measuring about 438,370 hectares with a total population of approximately 1,750,830 individuals calling it home. The climactic conditions are typically tropical with two discernable seasons; these are wet and dry (Tedla *et al*. 2018).

Geographically, the Wolaita Zone is located between 7° 00' North latitude and 37° 45' East longitude at the edge of the East African Great Rift Valley. It is bordered on the south by Gamo Gofa, on the west by the Omo River which separates it from Dawro, on the northwest by Kembata Tembaro, on the north by Hadiya, on the northeast by the Oromia Region, on the east by the Bilate River which separates it from Sidama Region, and on the southeast by Lake Abaya which separates it from Oromia Region (Olango *et al*., 2014).

To undertake this study, we focused on five key locations within Wolaita Zone including Boloso Sore Woreda, Boloso Bonbe, Damote Gale Woreda, Kindo Didaye and Kindo Koysha Woredas. Every region has its unmistakable traits that make it stand out from others. The western part of the zone - Boloso Sore - holds fertile soil leading to high agricultural activity while coffee production remains Boloso Bonbe's speciality towards the east zone. On central grounds lie two woredas-Kindo Didaye and Kindo Koysha known for their agricultural prowess. In contrast to these regions lies Damote Gale Harshen situated up north possessing abundant water resources too important to ignore Nonetheless, Wolaita Sodo City takes center stage as a significant economic hub being declared capital city of Wolaita Zone.

The Wolaita people are renowned for their rich cultural legacy that incorporates distinctive agricultural methods influenced by traditional customs and beliefs. Furthermore, the study location brims with various flora and fauna species alongside crops grown by farmers in the vicinity. All said this makes the Wolaita Zone an exclusive and lively area brimming with exceptional natural resources mingled with cultural nuances.

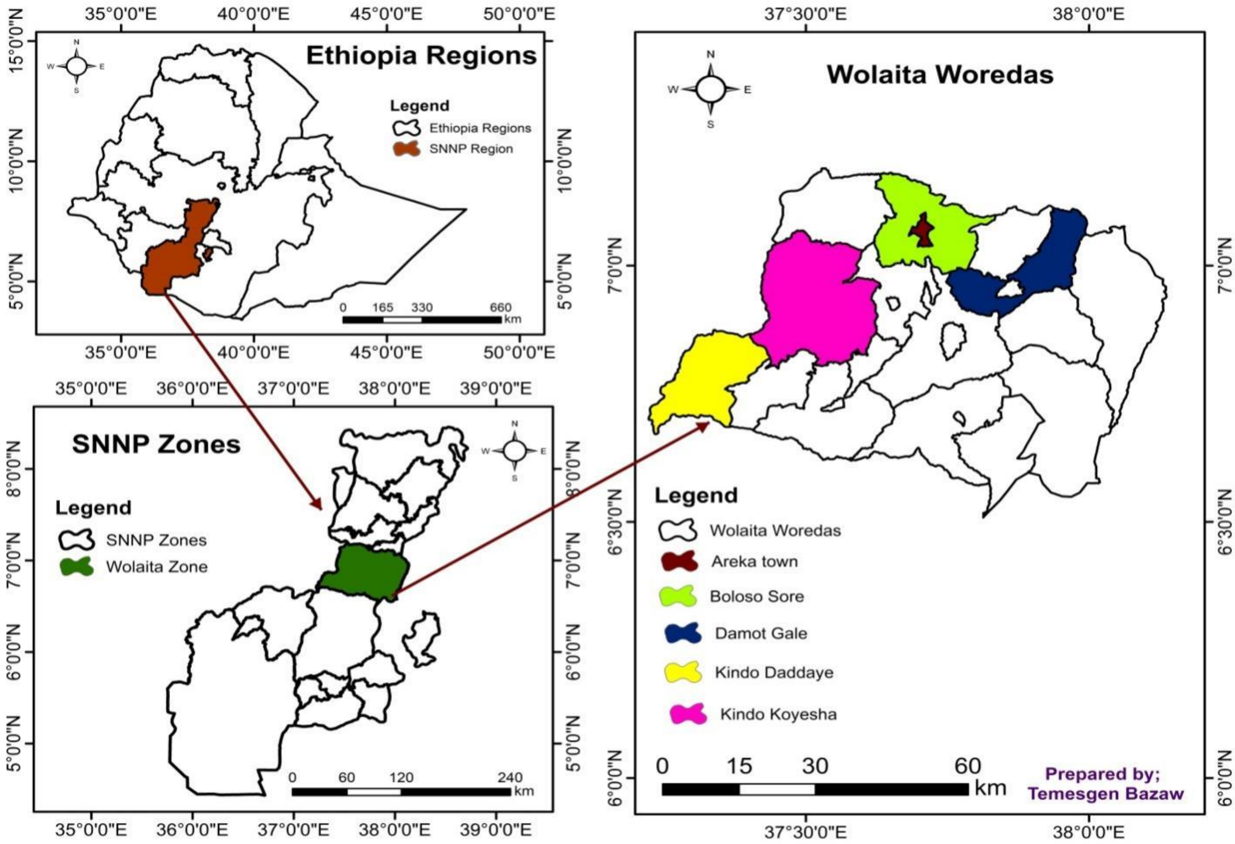

Figure.3.1: Location Map

3.2 Sampling Procedure

A stratified random and simple random sampling procedure was followed to define the sampling unit. Based on the three traditional agro-ecological zones of Ethiopia, lowland <1,500 m, midland 1,500-2,500 m, and highland >2,500 m above sea level (Ababa, 1998), the astronomical observation system and folklore of Wolaita were stratified in terms of elevation ranges. Boloso Sore woreda, Boloso Bonbe, Kindo Didaye woreda, Kindo Koysha woreda, and Damote Gale woreda were randomly selected. In the process of Woreda selection, key informants comprising agricultural officers and Development Agents (DAs) for the agricultural activity were consulted. And also consultations were made with the society chief and society elders in tribal communities on the advice of visitors. This included the elderly and sky readers.

A total of 25 households were randomly drawn from resident booklets in the 5 selected Woreda and considered as the overall sample size for the study. Types of plant seedlings were selected randomly from selected Woreda of the Boloso Sore woreda, Boloso Bonbe, Kindo Didaye woreda, Kindo Koysha woreda, and Damote Gale woreda for planting and transplanting (figure 3.2). And also the trees to be felled were identified and authenticated in the area with the assistance of experienced farmers and elders (figure 3.3).

Figure.3.2. Different plant seedlings that were identified and authenticated to plant with the assistance of experienced farmers and elders.

Figure.3.3. Felled trees with the assistance of experienced farmers and elders.

3.3 Data Type, Source, and Collection Methods

The study conducted in the Wolaita community involved the active participation of community knowledge holders such as sky readers, tribal chiefs, farmers, headmen, visitors, and community elders. They were involved in the research process from planning to data analysis, including the selection of study cases and data collection. The research findings were validated in each selected Woreda.

The study utilized both qualitative and quantitative approaches, with primary data mostly obtained through the qualitative method. The quantitative data was used for statistical analysis and to support the main arguments in the study. The qualitative method was used to gather data on farmers' attitudes and willingness to cut trees and plant seedlings, while structured questionnaires were used to collect quantitative data on demographic characteristics and other basic information from sample households. Additionally, focused group discussions and key informant data collection tools were also employed.

Ensuring the respondents' interest in the survey work was a top priority in the study. Sky readers, tribal chiefs, farmers, headmen, and community elders were among the key informants who may have been uncooperative unless their concerns were addressed seriously. To gain their trust, the objectives of the survey and the direct and indirect benefits to them were carefully explained to the respondents. The chairpersons of the respective rural kebeles were approached first, and efforts were made to convince them of the study's objectives.

The study used a modified structured interview schedule to collect primary data through personal interviews with sample sky readers and other key informants, such as tribal chiefs, farmers, headmen, and community elders. To ensure the reliability of the survey data and minimize technical and linguistic issues, the researchers provided appropriate supervision during data collection. Open-ended and closed-ended questionnaires were used to gather necessary information from the sample respondents, and the questionnaires were prepared in the Wolaitic version. Additionally, the community's indigenous knowledge was tested by collecting data from sample trees, plants, and seedlings through cutting and planting trees in different phases of the moon. The community farmers, elders, sky readers, and agricultural and rural development offices participated in this process, and their knowledge, thoughts, and opinions were incorporated into the study. The participants were encouraged to take part in the study.

3.4 Data Analysis and Presentation

Qualitative data in the form of audio-taped interviews were transcribed and translated from the Wolaitic version into English. The researchers typed interview and participant observation notes and conducted content analysis. Simple statistical equations were used to analyze the collected data. Additionally, the data was examined in parallel with Newton's law of gravity to determine the gravitational pull of the Moon and its effect.

According to Newton's law of gravity, the force between two masses is inversely proportional to the square of the distance between them. Using "Earth" and "moon" to indicate the relative masses of the objects (Orlov, 2010), we write

$$F = \frac{GM_{earth}m_{moon}}{r^2} \quad (3.1)$$

The mean and standard deviation of the triplicate test were calculated using statistical equations, and the data was presented using tables, graphs, and figures. The data came from closed-ended questions, random samples, counting, etc. In this research study, quantitative data from the questionnaires were checked, coded, and analyzed using Excel. Validation checks were conducted throughout all phases of research to ensure the highest level of data accuracy. Any unclear or missing information was clarified or collected by returning to informants and reviewing issues and concepts. Then, both primary and secondary data were presented using simple statistical tools like tables, bar charts, Word, Excel, and other methods to facilitate the interpretation of the collected data.

CHAPTER FOUR

PRESENTATION AND DATA ANALYSIS OF FINDINGS

4.1 Introduction

This chapter presents the results of research and qualitative discussions on issues related to agriculture and astronomical rhythms, as well as Celestial Objects in the Wolaita community. The first section assesses the history of cultural astronomy and the Celestial Objects used by the Wolaita community, with the aim of investigating the basic components of Wolaita indigenous knowledge and astronomy. The second part confirms Wolaita cultural beliefs regarding the effects of astronomical rhythms on agricultural production and the health of plants, with the aim of verifying community beliefs on the effects of celestial objects on agricultural production and providing hypotheses for the reasons behind these effects. The third part discusses the socio-economic, educational, progressive, and cultural contributions of cultural astronomy in Wolaita. Finally, the challenges faced by cultural astronomy in Wolaita today are discussed. The discussion is based on data gathered through key informant interviews, focus group discussions, archival observations, and experiments.

4.2. An Assessment of the History of Cultural Astronomy Begin in Wolaita

The history of Wolaita can be traced back to the prehistoric period, as evidenced by archaeological excavations that have revealed the existence of major caves where the Wolaita people used to live thousands of years ago (Hailu, 2019). The Wolaita community is composed of diverse clans, numbering around 200 in the Wolaita region and neighboring areas such as Gamo, Gofa, Dawuro, Kontta, and Basketto (Tedla *et al*., 2018). Out of these clans, only seven primarily use celestial objects, with four being the most well-known. These clans in Wolaita have named their small goddesses after celestial objects and believe that they created these objects. The Wolaita people hold the belief that spirits and deities inhabit the stars and other celestial bodies, and that these entities have a direct influence on their lives. In addition to their belief in the influence of spirits and deities on their lives, the Wolaita people also used celestial objects for practical purposes such as calibrating calendars and determining appropriate agricultural activities. However, the introduction of modern practices, including Christian religious ideology and costly artificial technologies, has had an impact on their indigenous cultural practices and beliefs. Therefore, it is important to conduct further research and documentation of the history of cultural astronomy in the Wolaita community to preserve their culture and gain a better understanding of the role of cultural astronomy in the wider context of Ethiopian astronomy.

4.3 Celestial Objects and Astronomical Rhythms Wolaita Community Uses

Astronomy plays a significant role in many communities worldwide, and the Wolaita community in southwestern Ethiopia is no exception. The Wolaita people have relied on astronomical rhythms and elements for centuries to guide their agricultural practices, determine the timing of significant activities, and educate about the cosmos. A recent study has investigated the educational, agricultural, and progressive implications of astronomy in the Wolaita community to test and asses the benefits of this knowledge and promotes its preservation.

The Wolaita community follows a lunar-solar calendar, which tracks the regular changes of the moon and the sun to determine the planting and harvesting seasons. Additionally, the community possesses extensive knowledge about constellations, such as the Pleiades star cluster, which helps determine the New Year's date and planting seasons. To further investigate the educational, agricultural, and progressive implications of these practices, researchers conducted a study using semi-structured questionnaires and tested the knowledge based on the response. Based on semi-structured questionnaires the community elders and farmers were interviewed to respond community's knowledge, traditions, beliefs, and practices related to astronomy.

Almost all respondents related that previously community members have extensive knowledge of the moon's cycles and the stars, as well as the role they play in farming, weather, and agricultural practices. That basic component of Wolaita knowledge is their indigenous knowledge. Their indigenous knowledge refers to the unique, traditional local knowledge existing within and developed around the specific conditions of a community indigenous to a particular geographical area, covering all aspects of life including management of the natural environment upon which their livelihoods and survival depend.

The Woliata community utilizes astronomical elements, such as stars, planets, comets and the moon, for various purposes based on their indigenous knowledge. By observing these elements, they are able to understand their significance and use them accordingly. According to the respondents, the community observes three specific stars - **Toorojiyo, Bakkaliyo, and Gojilliyaa** - to determine seasonal cycles, rituals, timing of daylight and darkness, navigation, crop planting and harvesting, as well as mating intervals. These stars are preferred for different purpose based on their inherent characteristics, appearance, positions, and movements.

Toorojiyo is described as a very bright star that moves from north to south that particular community and follows the moon (figure 4.1). It is the first brightest star of the night and stays in the sky throughout the year, but not throughout the night. It is considered the evening star and is used by the community for timing of dark light navigation. According to one respondent, the appearance of this star depends on the characteristics of the month. If the day is short and the night is long, it stays in the sky for four (4) hours starting from its rise. For months where the day is long and the night is short, it stays for eight (8) hours in the sky starting from its rise. For months where the day and night are equal, it stays for six (6) hours in the sky starting from its rise.

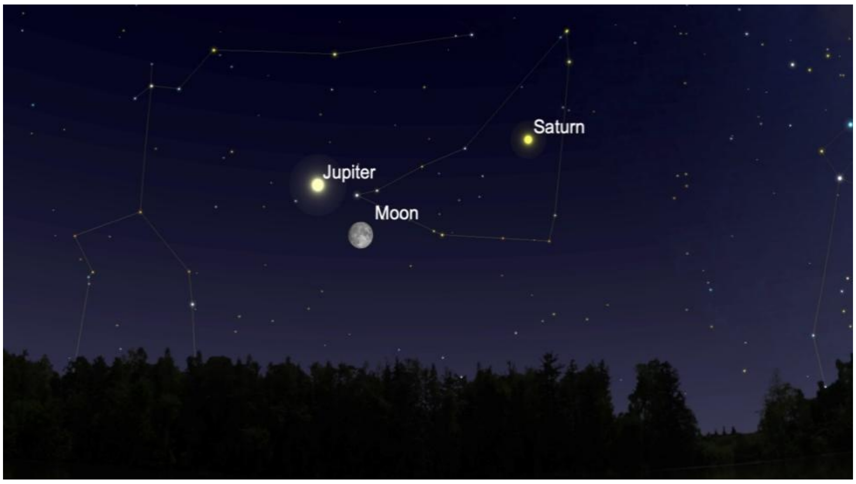

Figure 4.1 Toorojiyo in the night daytime sky which is Jupiter in the scientific name
(Source: space.com/Jupiter)

Bakkaliyo is described as the morning star that comes up very early in the morning and moves very slowly from east to west for that particular community (figure 4.2). It is also the last very bright star before morning. According to the respondents, the community uses it for timing of daylight navigation, specifically for navigating the morning of the day. They also added that they know it is morning when Bakkaliyaa rises and the sky is red, which they call "**Baazaoy zoo'iyes**" or "red sky in the morning". During this time, travelers who sleep out in the open would see it and know it is time to resume their journey. Young women and girls also wake up during this time to start doing their daily chores, and the community starts all activities such as farming, as the farmers wake up to farm.

Figure 4.2 Bakkaliyo in the morning sky which is Venus in the scientific name (Source: skyatnightmagazine.com/Venus-morning-star)

Gojilliyaa is described as a group of stars, consisting of six stars that never set or go down (figure 4.3). They stay in the sky until the sun rises and move from north with Hadya and Kembata Tembaro Zones to west with Dawuro Zone for that particular community. According to the respondents, it announces the start of the planting season, which they call Badhdheesaa. The community uses Gojiliyaa to determine seasonal cycles, including the planting and harvesting seasons. It is used as a celestial marker to signify the beginning of the winter season. As most people were dependent on agriculture, the prediction of seasonal changes and the first rains was a key factor in their lives. It was linked to agriculture and used to mark the time for cultivation.

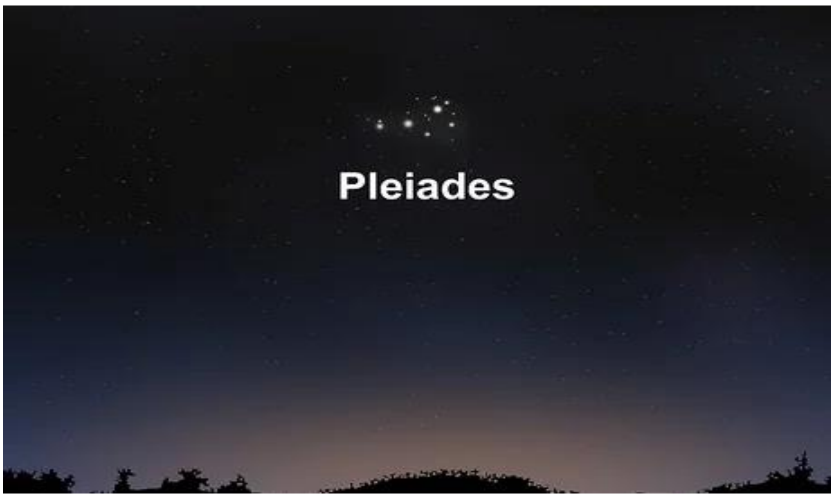

Figure.4.3 Gojiliyaa in the night daytime sky which is Pleiades in the scientific name (Source: wikiHow.com)

They determine the planting seasons depending on the Gojiliyaa. They point to three positions, namely, the Kembata Tembaro zone, the Dawuro zone, and the center of that particular community. As the community elders, when the Gojiliyaa is near the Kembata Tembaro zone, they call the month "heezza agina" or the 3rd month. Hence, when the Gojiliyaa moves and is near the center of that community, they call the month "ichchashiyaa agina" or the 5th month. After ichchashiyaa agina, the Gojiliyaa slightly shifts from the center to the Dawuro zone. In the two months, they know their planting time, which is "Badhdheesaa" or the time to cultivate and do their agricultural activities. In this time, they start to cultivate, plant seedlings, and sow seeds. Finally, the Gojiliyaa moves to the Dawuro zone, and they call the month "Tammanne naa’’aa aginaa" or the 12th month.

In addition to using Gojiliyaa to determine seasonal cycles, the community also assigns seasons based on the movement of Gojiliyaa from its rise position in Kembata Tembaro Zones to its setting position in Dawuro Zone. According to the respondents, there are four seasons in the community that depend on Gojiliyaa: Ofinttaa (spring), Boniyaa (summer), Gabbaa (autumn), and Balgguwaa (Silaa) (winter).

Ofinttaa (spring) is the season of the year between winter and summer during which plants bring forth leaves and flowers. The community knows it is Ofinttaa depending on the position of Gojiliyaa, which is near the Kembata Tembaro zone. Boniyaa (summer) is the season of the year that is the longest and typically hottest day of the year. The community knows it is Boniyaa depending on the position of Gojiliyaa, which is near the center of that community. Gabbaa (autumn) is the third of the four seasons when deciduous trees lose their leaves. The community knows it is Gabbaa depending on the position of Gojiliyaa, which is slightly shifted from the center to Daruwo zone. Generally, they call this season Badhdheesaa wodiyaa. Finally, Balgguwaa (Silaa) (winter) is the fourth season of the year, typically rainy. The community knows it is Balgguwaa (Silaa) depending on the position of Gojiliyaa, which has moved to the Dawuro zone.

Similarly, the respondents indicated that the Wolaita community observes moon phases to determine seasonal cycles for agricultural activities and for women to keep track of their menses and fertility cycles. They predict the month's future using the moon. They also use the moon's position to predict the likelihood of rainfall or drought and plan other activities based on their agricultural cycles. During the field survey, community elders and farmers talked about ceggenna, which is linked to the moon phases. When asked what ceggennaa means, 80% of the interviewed elder and farmer respondents gave the same answer. They said ceggennaa refers to the phenomenon when cereals are sown with minimum crop destruction or drying, cutting plants by blade eaten by weevil and termite, and planting and transplanting seedlings leads to dry and wither. This phenomenon occurs during the new moon and full moon phases in one moon cycle. Depending on the moon phases, our ancestors divided ceggennaa into two. These are:

1. Xeero ceggennaa and;
2. Goobana ceggennaa

These two ceggennaa occur within one cycle of the moon. Xeero ceggennaa occurs when the moon is dark (during new moon), and Goobana ceggennaa occurs when the moon is full (during full moon) (figure 4.4).

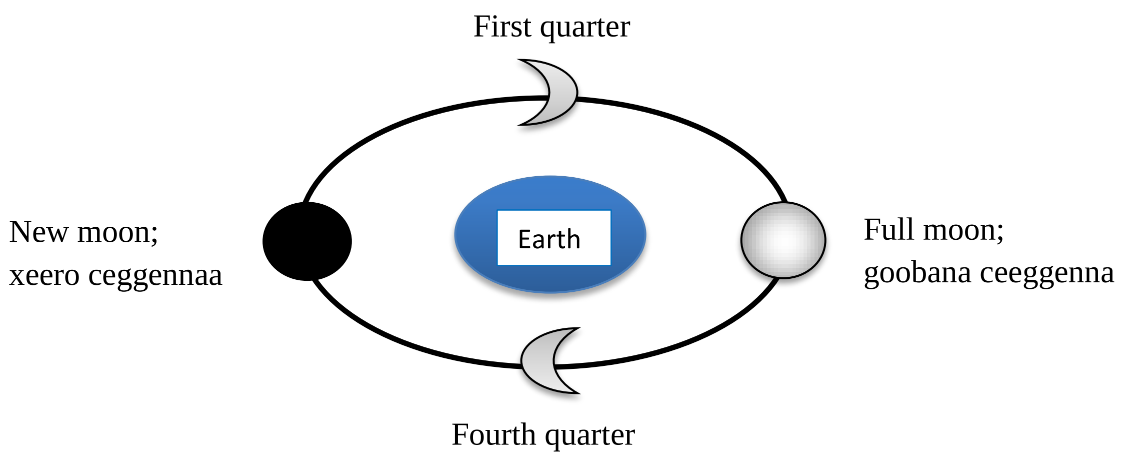

Figure 4.4 Moon cycle refer to Wolaita community ceeggenna counting.

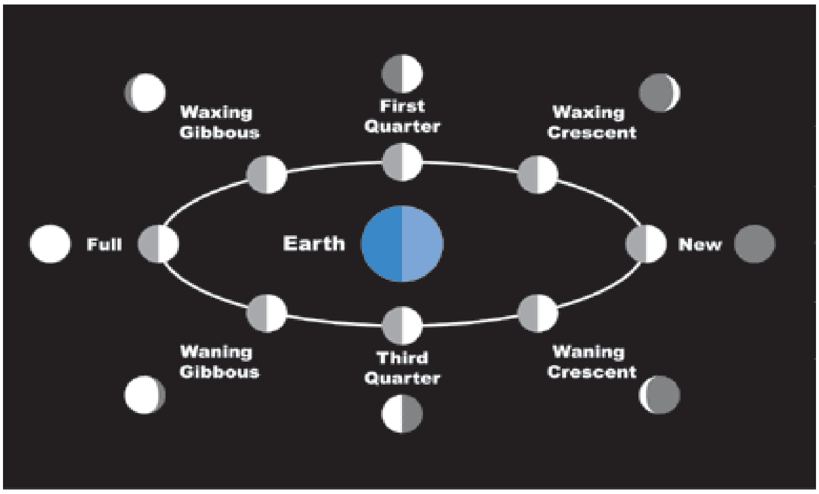

Figure 4.5 Moon phases refer to modern astronomy (source: Nasa.com)

In the cycle of the moon, Xeero ceggennaa takes three (3) days. However, some respondents say it takes two (2) days, and others say it takes one (1) day, depending on their position in life. Nevertheless, they wait for three (3) days until the xeero ceggennaa clears for their activity. On the first day, the moon is invisible (the sky is dark), and they are called Haatan peise. This happens when the illuminated portion of the moon is completely in the sun's shadow (too close to the sun), and the new moon appears on that day. On the second day, the lit (0.1%) disc of the moon is illuminated near a mountain that cannot be seen by all people. On this day, the Jirraa can bless the moon to be visible for the people. "Jirraa" is the man who blesses the moon to reveal the lit disc. Other respondents from other areas also indicated that the micro moon is blessed by the Durowaa man. Additionally, some respondents added that pregnant women see the lit disc first before anyone else because they count their pregnancy months. On the third day, the moon in front of the mountain appears in the sky, increased from the lit disk. At this time, all people can observe it clearly. On this day, the community believes that the xeero ceggennaa is clear.

After the clear of xeero ceggennaa up to 8^{th} days there is no ceggennaa respondents say those days the bright days. On the 8^{th} day (means after the rise of the moon) the goobana ceggennaa is entering and it takes five (5) days per month counting from 8^{th}-12^{th} days including 8^{th} day. But some respondents says it take four(4) days and also others says it takes six(6) days depending on their position of live. Nevertheless they wait five (5) days until the supermoon is visible. On the 12^{th} day, the goobana ceggennaa becomes clear. They determine the start of the goobana ceggennaa by observing the fully circular moon with the naked eye, and they know it has ended when the moon becomes a supermoon. They call it Dorsaa dagantoo, which means 'super moon'. Starting from that day up to the fall of the moon they believe the ceggenna is clear and they don't fear for it, predict no effects come to our agricultural production and animal fertility.

The respondents give reasons why they count ceggennaa and worry about it, as this phenomenon affects agricultural production and animal fertility. During Xeero ceggennaa, the community cannot engage in activities such as sowing crops, cutting trees, planting seedlings, or having sexual intercourse. They believe that if they sow crops during this time, the crops will fall prey to weevils, leading to minimum crop destruction, spoilage, and loss. If they cut trees, the trees will be eaten by termites and attacked by plant diseases. If they plant seedlings, the plants may wilt and not grow properly. They also believe that if animals mate during this time, their fertility will be reduced, and any children born during this ceggennaa will not grow properly, or may become flaccid. Instead, during this time ploughing and tillage activities are undertaken.

Similarly to Xeero ceggennaa, respondents mentioned that during the goobana ceggennaa, they cannot engage in activities such as sowing crops, cutting trees, planting seedlings, transplanting seedlings, harvesting crops, or having sexual intercourse. However, they said that the difference between Xeero ceggennaa and the goobana ceggennaa is that the latter is more dangerous and hazardous for agricultural production and animal fertility. They fear and worry more during these days because they believe that if they sow crops during this time, the crops will be highly affected by weevils, leading to maximum crop destruction, spoilage, and loss. If they cut trees, the trees will be eaten by pests, rendering them totally unusable, and attacked by plant diseases. If they plant seeds, the plants may not grow at all, completely dry out, or have clubbed roots, making them unsuitable for growth. They also believe that if animals mate during this time, their fertility will be reduced due to menstruation flow. However, they believe that children born during this ceggennaa will grow properly. Instead, they believe that it is the best time for killing weeds, thinning, pruning, and cutting trees to dry in this goobana ceggennaa. Overall, it is more risky than Xeero ceggennaa.

4.4. The Experiment on Wolaita Cultural Beliefs of the Effects of Astronomical Rhythms on Agricultural Production and Health of Plants

Grounded on scientific experimentation around the world, numerous community beliefs pertaining to lunar cycles are proven true by various researchers. They discovered that plants' growth and development are significantly impacted by it from flowering timing to photosynthesis rates, even affecting water uptake for plants (Raven *et al.*, 2006; Semmens, 1923; Tran *et al*., 2023). Additionally, it affects germination timing as well as seedling emergence rates (Kollerstrom *et al*., 2001; Zürcher *et al*., 2014). Moreover, aside from lunar cycles' effects on agriculture production optimization purposes through different astronomical rhythms such as solar cycle or seasonal cycle or diurnal cycling were discovered (Stanislaw Iwaniszewski, 2006; Mayoral *et al*., 2020).

In addition to the effects of astronomical rhythms on agricultural production, researchers have also studied the effects of astronomical rhythms on the health of plants (Zürcher *et al*., 2014). Studies have shown that the lunar cycle can affect the growth and development of plants in a number of ways, including the timing of flowering, the rate of photosynthesis, and the amount of water uptake by plants (Schad, 1999; Sivasankar *et al*., 2021; Spiess, 2000). However, they suggested further scientific experimentation should sort out these matters.

To verify the beliefs of the Wolaita community, researchers conducted an experiment by planting and transplanting seedlings, as well as felling trees, in different phases of the moon. Fifteen trees were felled every month for five months between January 2022 and December 2022 to test this. Three out of the fifteen trees were felled in one moon cycle. Five out of the fifteen trees were felled during Xeero ceggennaa (new moon), another five were felled during Goobana ceggennaa (full moon), and the remaining five were felled on other phases of moon.

Similarly, twenty seedlings were planted and transplanted every month for five months between March 2022 and August 2022, after determining the planting season using Gojiliyaa. Four out of the twenty seedlings were planted and transplanted in one moon cycle. Five out of the twenty seedlings were planted and transplanted during Xeero ceggennaa, another five were planted and transplanted during Goobana ceggennaa, and the remaining five were planted and transplanted on phases of moon.

4.4.1. Results and Discussion

The results were shown in the figures below. The trees attacked by weevils and diseases were shown in Figure 4.6a and b. The weevils created powders and holes in the trees within one month, and these holes looked covered with powders (Figure 4.6a and b). It is estimated that more than several thousand weevils were in the holes. Figure 4.7a and b showed dried and withered plant seedlings during planting and transplanting in ceggennaas. Figure 4.8a and b showed grown plant seedlings planted and transplanted during in first and third quarter moon phases. The plant seedlings were dried and withered within 1-2 weeks, fifteen days after planting and transplanting in ceggennaa, while grown plant seedlings took 2 weeks to one month to show growth.

a.  b. 

Figure 4.6 Attacked trees in weevil and diseases during in both ceggennaa

a..  b. 

Figure 4.7 Dried and withered plant seedlings planted and transplanted during in both ceggennaa

a.  b. 

Figure 4.8 Grown plant seedlings planted and transplanted during in first and third quarter moon phases

Table.4.1 Data on moon phases and incidence of weevil and diseases attack on the felled trees

Moon phases	Number of felled trees	Number of attacked trees in weevil and diseases; 15 felled of and ration in %
New moon (waxing)	5	4(26.7)
First quarter (waxing)	2	0(0)
Full moon (waning)	5	4(26.7)
Third quarter (waning)	3	1(6.7)

Table 4.1 shows that the incidence of weevil attack on felled trees varies across the different moon phases, as evidenced by the different values of incidence of weevil and diseases attack on the felled trees for each moon phase. There is a higher percentage of attacked trees (by weevils and diseases) during the new moon and full moon phases, with 80% of trees being affected from five felled of during each of those phases. With 26.7% of trees were attacked from 15 felled of in new moon phases. And also 26.7% of trees were attacked in full moon phases. In the first quarter (waxing) phase no trees were attacked from 2 felled trees and 0% of trees were attacked from 15 felled of in ratio, while the third quarter (waning) phase one (33.3%) tree were attacked from 3 felled trees and a small percentage of attacked trees (6.7%) from 15 felled of in ratio.

So, there is correlation between the felling dates to the incidence of weevils attack on the felled trees, we can see there is a high correlation when considering the relationship between attack rate and felling dates occurring around new or full moons. It can be deduced that tree felling performed around new or full moons may lead to higher probabilities for pests or diseases damaging them compared to those done in first or third quarter phase.

Table.4.2 Data on lunar phases and dried and withered seedlings

Moon phases	Number of planted and trans planted seedlings	Number of dried and withered seedlings; 20 planted and transplanted of and ration in %
New moon (waxing)	5	4(20)
First quarter (waxing)	5	2(10)
Full moon (waning)	5	5(25)
Third quarter (waning)	5	1(5)

Table 4.2 indicates an interesting connection between different phases of the moon and the success rate of newly planted or transplanted seedlings fare as a result. During new moons specifically, we see a higher than average number (80%) track towards failure (withered or dried up) within a weeks when compared to other phases; meanwhile we were observed that all plant seedlings (100%) fail to germinate and growth under full moons without fail each time we plant them. We also found interesting results when growing according to waxing and waning moon timings. About 10% of plant seedlings were dried and withered from five planted and transplanted seedlings during first quarter moon phase. And also about 5% of plant seedlings were dried and withered from five planted and transplanted seedlings during third quarter moon phase.

This data suggests that the moon phases may have an impact on the success of planting and transplanting seedlings and its success varies depending on the moon phase. Specifically, it appears that the first and third quarter phases were indicated more favorable for plant growth, as they had lower percentages of dried and withered seedlings. The full moon phase (waning) had the highest percentage of dried and withered seedlings, while the new moon phase (waxing) had a slightly lower but still significant percentage.

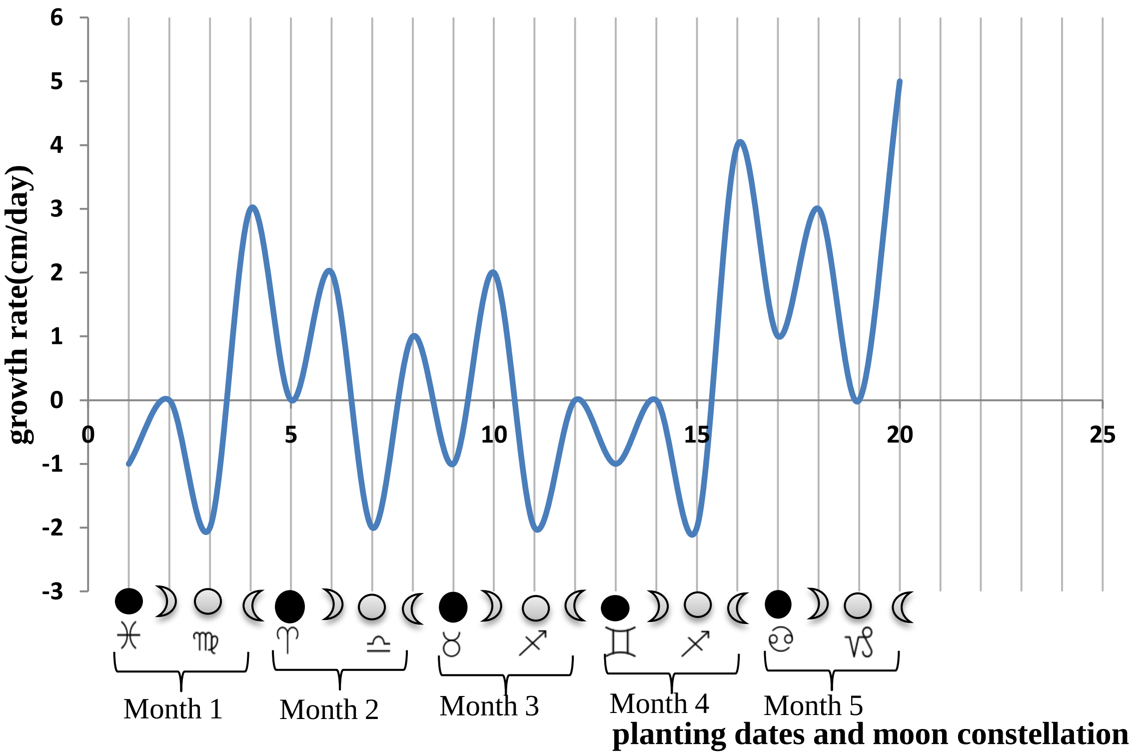

Figure.4.9. Relationship between planting dates and growth rate (cm/day) of seedlings with in five month. (For a definition of lunar constellations see glossary)

Key: - **Month1**:- April-1-New moon, April-9-first quarter, April-16-full moon, April-23-last quarter;
Month 2:-April-30-ewmoon, May-9-first quarter, May-16-fullmoon, May-22-last quarter;
Month 3:-May-30-Newmoon, June-7-first quarter, June-14-fullmoon, June-21-last quarter**;**
Month 4:-June-29-new moon, July-7-first quarter, July-13-full moon, July-20-last quarter;
Month 5:-July-28-newmoon, August-5-first quarter, August-12-full moon, August-19-last quarter.

Figure 4.9 shows the growth rates of seedlings and planting dates in different moon phases and moon constellations for different months of planting seedlings. The growth and growth rate were measured by observing the growth and dried/withered state of seedlings in cm/day after planting and transplanting in different moon phases and constellations. The experiment yielded positive, negative, and zero values during measurement. Positive values indicate grown plant seedlings, negative values indicate dried plant seedlings, and zero values indicate withered plant seedlings.
The highest growth rate of plant seedlings was recorded in month 5, while plant seedlings planted and transplanted between month 3 and month 4 were more likely to dry and wither. Additionally, plant seedlings planted and transplanted during full and new moon phases resulted in negative and zero values for four months. This indicates that the plant seedlings planted and transplanted during Xeero Ceggennaa and Goobana Ceggennaa are more likely to dry and wither. These results confirm the traditional planting dates for seedlings in the area.

The experiment results suggest that planting and transplanting plant seedlings during certain moon phases and constellations can affect their growth and survival rates. The results also indicated that cultural use of astronomical rhythms such as lunar cycle, solar cycle and star constellation has significant impacts on agriculture to enhance crop yields, the soil fertility and plants resilience to pests and diseases not only that it also for faster germination. It confirms that the consideration and practical application of planting and felling according to lunar cycles most appropriate for planting seedlings, felling trees, and for the growing of plant seedlings, all specialty areas which strive to achieve the highest quality in the final product.

4.4.2 Hypotheses

In our experiment, we aimed to understand the effects of moonlight, planet light, and starlight on plant development and the growth of crops, as well as the felling dates of trees based on Wolaita myth. We hypothesized the reasons why plant seedlings dry up and wither, and why felled trees are attacked by weevils and diseases during ceggennaa (full and new moon). The two most profound influences of the Moon on our environment are the light it reflects from the Sun and its gravitational influence. The light reflected from the Moon has the same visible spectrum as sunlight at night.

The Sun emits $3.9\ x\ 10^{26} Js^{-1}$ of total electromagnetic radiation. The total solar radiation intercepted is $1.33\ x\ 10^{16} Js^{-1}$. The lunar albedo, with little dependence on wavelength, is 0.1, so the reflected radiation is $1.33\ x\ 10^{15} Js^{-1}$. Radiation flux of moonlight is equal to $2.5\ x\ 10^{-9}\ or\ 2.5\ nmol\ of\ photons\ m^{-2}s^{-1}$ (Raven *et al*., 2006). However, the amount of light reflected from the Sun to the Moon varies depending on the position of the Moon in its orbit around the Earth and the position of the Earth in its orbit around the Sun.
In the new moon phase, the light reflected from the Sun to the Moon is completely rejected, while in the full moon phase, about 12% of the sunlight that falls on it is reflected. The range of $0.5 - 5 nmol\ of\ photons\ m^{-2}s^{-1}$ values of photosynthetically active radiation (PAR) hits the earth in both cases, which means that plants and crops cannot receive a balanced amount of light. This amount of PAR during the full moon phase can influence photosynthesis, making it an important factor for plant growth and development and moisture levels of soil. For these reasons, it may be the case that crops and plant seedlings dry up and wither.

In addition to sunlight, planet light, which is the light emitted by planets like Venus and Mars and starlight, which is the light emitted by stars can play a role in enhancing crop yield and plant growth in greenhouse agriculture. Despite their advantages, however, these types of light may impede the plants' detection of blue-green region light and cause inconsistency in seedling drying and withering. This is because the spectrum of planet light may not offer sufficient wavelengths for ideal photosynthesis and plant development.

Another effect is may be the gravitational pull that the moon has on the Earth. The Moon's gravitational pull causes the Earth to bulge slightly on the side facing the Moon, creating a tidal bulge. These tidal bulges cause small, regular variations in the Earth's shape, as well as in the length of the day, ultimately impacting the moisture content of the soil of crops and plants. It is believed that during the new and full moon phases (ceggennaa), there is a potential decrease in soil moisture levels that can affect the ideal environment for seed germination and plant growth. Additionally, the dryness and withering of plant seedlings, as well as the attack of weevils and disease on felled trees during new moon and full moon may be caused by the bulging out of moisture levels and the absorption of water from felled trees.

It's known that fluctuations in gravitational attraction between Earth and its natural satellite derive from underlying factors like phases or distance. However, highest levels of gravitation arise during periods when proximity between Moon and Earth peaks such as full or new moons. Utilizing an established mathematical equation can help discern accurate measurements for gravitation generated by every shift in phases which influence our planet's relationship with Moon:

$$F = \frac{G M_{earth} m_{moon}}{r^2} \qquad (4.1)$$

Where F is the gravitational force, G is the gravitational constant ($6.6743 \, x \, 10^{-11} Nm^2/kg^2$), $m_{moon}$is the mass of the Moon ($7.342 \, x \, 10^{22} \, kg$), $M_{earth}$is the mass of the Earth ($5.9722 \, x \, 10^{24} \, kg$), and r is the distance between the centers of the Moon and the Earth.

The distance between the Moon and the Earth changes depending on the phase of the Moon. The reason is that the Moon follows an elliptical path with a moderate level of eccentricity equal to 0.0549 on average. During perigee (minimum distance) we can observe the supermoon phenomenon firsthand when it appears slightly larger than usual in our sky while being merely at a distance of only ~363 thousand kilometers from us! Conversely during apogee (maximum separation) due to its farther distance (~407 thousand kilometers away) we might notice that it looks slightly smaller than usual - thus nicknamed "micromoon."

Table 4.3 Moon phase of five month starting from April to August 2022 with their apparent distance from Earth in km **(**Source: https://heavens-above.com/Moon.aspx)

New moon			**First quarter**			**Full moon**			**Last quarter**		
Month	**Day**	**Range (km)**	**Month**	**Day**	**Range (km)**	**Month**	**Day**	**Range (km)**	**Month**	**Day**	**Range (km)**
April	1	388,336	April	9	401,855	April	16	370,186	April	23	373,028
April	30	396,389	May	9	394,740	May	16	360,889	May	22	376,600
May	30	404,341	June	7	390,236	June	14	357,459	June	21	386,558
June	29	406,475	July	7	379,570	July	13	357,446	July	20	391,484
July	28	404,241	Aug.	5	375,323	Aug.	12	363,593	Aug.	19	399,973
Total	1,999,782km			1,941,724 km			1,809,573km			1,927,643km	

As per data recorded in table 4.3 for April-August of 2022 period: while on a full Moon day Earth's and Moon's centers are approximately separated by around 1,809,573 km, during new Moon this gap is roughly 1,999,782 km. Additionally, on June twenty-ninth an observer spotted micromoon while it was approaching apogee at an impressive distance of about 406,581 km. However, on June fourteenth as well as July thirteenth, two supermoons were famous among stargazers where their distances 357, 434km and 357,264kms respectively were believed to be closest (Source: http://astropixels.com/ephemeris/moon/moonperap2001.html). Using these values, we can calculate the gravitational force of the new, and full moon on the Earth:

Full moon:

$$F = \frac{GM_{earth}m_{moon}}{r^2}$$

$$F = \frac{6.6743 \ x \ 10^{-11} Nm^2/kg^2 (7.342 \ x \ 10^{22} \ kg \ x 5.9722 \ x \ 10^{24} \ kg)}{(1{,}809{,}573 \ \text{km})^2}$$

$$F = \ 8.937 \ x \ 10^{18} \ N$$

New moon:

$$F = \frac{GM_{earth}m_{moon}}{r^2}$$

$$F = \frac{6.6743 \ x \ 10^{-11} Nm^2/kg^2 (7.342 \ x \ 10^{22} \ kg \ x 5.9722 \ x \ 10^{24} \ kg)}{(1{,}999{,}782 \text{km})^2}$$

$$F = 7.318 \ x \ 10^{18} \ N$$

Therefore, the data recorded from April to August in year 2022 have given us insights about how much gravity different lunar phases exert over our planet with numbers pegged approximately at $8.937 \ x \ 10^{18} \ N$ and $7.318 \ x \ 10^{18} \ N$ for Full Moon and New Moon respectively. Moving ahead with these facts, it seems logical to conclude that periods marked by Full Moon brought about comparatively greater 'pulling' power than the New Moon phase.

New moon micromoon in June 29, 2022:

$$F = \frac{GM_{earth}m_{moon}}{r^2}$$

$$F = \frac{6.6743 \ x \ 10^{-11} Nm^2/kg^2 (7.342 \ x \ 10^{22} \ kg \ x 5.9722 \ x \ 10^{24} \ kg)}{(406{,}581 \ \text{km})^2}$$

$$F = 1.77 \ x \ 10^{20} \ N$$

Full moon supermoon in June 14, 2022:

$$F = \frac{GM_{earth}m_{moon}}{r^2}$$

$$F = \frac{6.6743\ x\ 10^{-11}Nm^2/kg^2(7.342\ x\ 10^{22}\ kg\ x5.9722\ x\ 10^{24}\ kg)}{(357{,}434\ \text{km})^2}$$

$$F = 2.29\ x\ 10^{20}\ N$$

Full moon supermoon in July 13, 2022:

$$F = \frac{GM_{earth}m_{moon}}{r^2}$$

$$F = \frac{6.6743\ x\ 10^{-11}Nm^2/kg^2(7.342\ x\ 10^{22}\ kg\ x5.9722\ x\ 10^{24}\ kg)}{(357{,}264\ \text{km})^2}$$

$$F = 2.2928\ x\ 10^{20}\ N$$

Therefore, New Moon Micromoon occurring on June 29, 2022 results in approximately $1.77\ x\ 10^{20}\ N$ gravitational force impact on Earth while Full Moon Supermoon for June 14 and July 13, 2022 generates roughly around $2.29\ x\ 10^{20}\ N$ and $2.2928\ x\ 10^{20}\ N$ respectively .The potency levels observed during these events prove to be higher than those produced by an average period of five months new or full moons phases. The data we collected also revealed severe dryness amongst our plant seedlings whenever any New Moon Micromoon or Full Moon Supermoon was present. Looking at figure 4.8 we found a significant negative score that spans between month 3 and month 4 including all three dates indicating an alarmingly high rate of dryness and withering among our plant seedlings during the aforementioned events. It is plausible that the gravitational pull generated by both celestial bodies the Moon and Sun for these instances could be causing excess moisture loss ultimately leading to this severe dehydration.

In addition to the effect of gravitational pull of the moon on greenhouse agriculture and Earth's atmosphere there may be the perturbation of moon orbit due to the Sun influence. Suppose that the Earth, the Moon and the Sun as a system of three mass points, the equation of Earth-Moon system can be derived as:

$$\ddot{\vec{r}} + \frac{G(E+m)\vec{r}}{r^3} = GM_{\circ}\left(\frac{\vec{\Delta}}{\Delta^3} - \frac{\vec{r}'}{r'^3}\right) \qquad (4.2)$$

Where $\vec{r}$ is the radius vector of the Moon, $\vec{r}'$ is the radius vector of the Sun and $\vec{\Delta} = \vec{r}' - \vec{r}$ is the radius vector of the Sun from the Moon (figure 4.5) and $E, m\ and\ M_{\circ}$ are the masses of the Earth, Moon and Sun respectively and G is the gravitational constant. In the left hand side equation (4.2) represents the principal force on the Moon due to the attraction of the Earth while in the right hand side it represents the tidal force on the Moon due to the Sun.

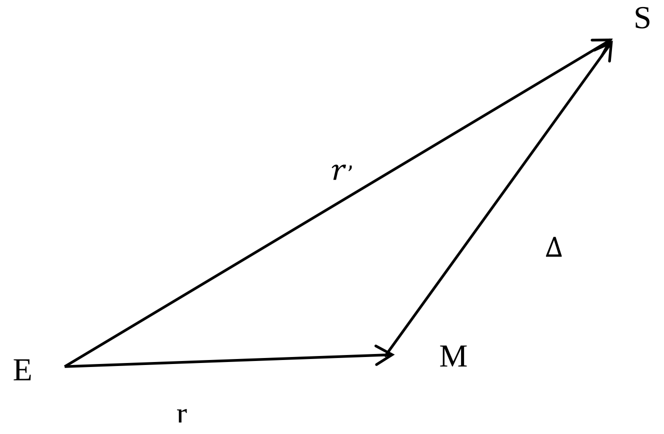

Figure 4.10 Geometrical representations of vectors $\vec{\Delta} = \vec{r}' - \vec{r}$

The terms in the right hand side of equation (4.10) can be expressed as the gradient of the disturbing function, R, written as:

$$R = GM_{\circ}\left(\frac{1}{\Delta} - \frac{\vec{r}.\vec{r}'}{r'^3}\right) \qquad (4.3)$$

Since $(r/r') \cong 1/400$ we obtain an expansion for R in terms of r/r'. In terms of the orbital elements we can express R. Some of the important terms are as follows:

$$R = \left(\frac{k^2 M a_{moon}^2}{a_{sun}^3}\right)\left[\frac{1}{4} + \frac{3}{8}e^2 - \frac{1}{2}ecosM - \frac{1}{8}e^2cos2M + \frac{15}{8}e^2\cos\{2(\Omega + \omega - \psi')\} - \frac{9}{4}e^2\cos\{2(\Omega + \omega - \psi') + M\} + \frac{3}{4}e\cos\{2(\Omega + \omega - \psi') + 2M\} - \frac{15}{8}e^2\cos\{2(\Omega + \omega - \psi') + 2M\} + \frac{3}{4}e\cos\{2(\Omega + \omega - \psi') + 3M\} + \frac{3}{4}e\cos\{2(\Omega + \omega - \psi') + 4M\}\right]. \qquad (4.4)$$

In the above expansion terms of higher order than two in e have been ignored. Where $a, e, \Omega, and\ \omega$ are the elements of the Moon's orbit and M is its mean anomaly. The angle ψ' is the mean longitude of the Sun. Utilizing the Lagrange's planetary equations we can estimates for the changes in the orbital elements with time to relate the time derivatives of the elements with the derivatives of the disturbing function with respect to the elements. It yields:

$$\dot{a} = \frac{2}{na}\frac{\partial R}{\partial \sigma},$$

$$\dot{e} = \left(\frac{1-e^2}{na^2 e}\right)\frac{\partial R}{\partial \sigma} - \left(\frac{\sqrt{1-e^2}}{na^2 e}\right)\frac{\partial R}{\partial \omega},$$

$$\dot{\sigma} = \left(-\frac{1-e^2}{na^2 e}\right)\frac{\partial R}{\partial e} - \frac{2}{na}\frac{\partial R}{\partial a},$$

$$\dot{\Omega} = \left(\frac{1}{na^2 \sin i\sqrt{1-e^2}}\right)\frac{\partial R}{\partial i},$$

$$\dot{\omega} = \left(\frac{-\cos i}{na^2 \sin i\sqrt{1-e^2}}\right)\frac{\partial R}{\partial i} + \left(\frac{\sqrt{1-e^2}}{na^2 e}\right)\frac{\partial R}{\partial e},$$

$$\frac{di}{dt} = \left(\frac{\cos i}{na^2 \sin i\sqrt{1-e^2}}\right)\frac{\partial R}{\partial \omega} - \left(\frac{1}{na^2 \sin i\sqrt{1-e^2}}\right)\frac{\partial R}{\partial \Omega}.$$

It may be convenient to use the mean anomaly $M = n(t-T) = nt + \sigma$ instead of σ itself, which is the coefficient of the secular acceleration. This implies that the perturbation function can be written in the form $R(a, e, i, \Omega, \omega, M)$. The solution of these equations shows that the elements $a, e, i, and\, T$ undergo only periodic changes, while the elements Ω, ω undergo both periodic and secular changes.

The moon appeared in apogee (A) on June 29, 2022 at an impressive distance of about 406,581 km. And also on June 14, 2022 as well as July 13, 2022, the moon appeared in Perigee (P) at distances of about 357, 434 km and 357,264 km respectively (table 4.4).

Table 4.4 Moon data of June 14, June 29 and July 13, 2022.

Date 2022	**Declination**	**Altitude**	**Radius (a)**	**Moon phases**
June 14	-25° 24' 19"	1.8°	357, 434 km	Full Supermoon (Perigee (P))
June 29	26° 49' 32"	-9.6°	406,581 km	New Micromoon (apogee (A))
July 13	-26° 48' 5"	-0.3°	357,264 km	Full Supermoon (Perigee (P))

From the data we can get the eccentricity of the Moon's orbit.

$$e = \frac{A - P}{A + P} \qquad (4.4)$$

The average eccentricity of Moons orbit on June 14 and June 29, 2022:

$$e = \frac{406{,}581 - 357{,}434}{406{,}581 + 357{,}434} = \frac{49{,}147}{764{,}015} = 0.0643$$

The average eccentricity of Moons orbit on July 13 and June 29, 2022:

$$e = \frac{406{,}581 - 357{,}264}{406{,}581 + 357{,}264} = \frac{49{,}317}{763{,}845} = 0.06456$$

Average distance between the Moon and the Earth on June 14 and June 29, 2022:

$$a = \frac{(406{,}581 + 357{,}434)km}{2} = 382{,}007.5\ km$$

Average distance between the Moon and the Earth on July 13 and June 29, 2022:

$$a = \frac{(406{,}581 + 357{,}264)\text{ km}}{2} = 381{,}922.5\ km$$

Average distance between the Moon and the Earth on June 14, 2022 and July 13, 2022:

$$a = \frac{(382{,}007.5 + 381{,}922.5)km}{2} = 381{,}965\ km$$

Therefore, the mean values of $a, e, and\ i$ are:

$$a = 381{,}965\ km, \qquad e = 0.06443, \qquad i = 5.145°23'$$

However, the general mean value of $a, e, and\ i$ are:

$$a = 384{,}400\text{ km}, \qquad e = 0.05490, \quad i = 5°09'$$

So, the elements of the Moon's orbits on June 14, June 29 and July 13, 2022 are varied due to various perturbations, such as the gravitational influence of sun and may be other planets in the solar systems. Meanwhile, 'a' varies periodically by ±13.8% and ±13.75%, being maximum at the new moon on June 29, 2022 and minimum at full moon on June 14, 2022 as well as July 13, 2022. Thus the period of the perturbation is half a synodic month. There is also an overall increase in 'a' causing an increase in the period of the Moon by about one hour, i.e. if the Sun was not there, the month would have been shorter by about one hour.

The inclination i vary periodically by small amounts with three different periods of half year, half sidereal month and half synodic month. The variation in inclination is ±23'. Therefore $\Delta i/i = 23'/5.145°23' = 4.468'$ i.e., the inclination varies by ±30%.

The integral of area h from celestial mechanics calculated by:

$$h^2 = \mu p = G(E+m)a(1-e^2). \qquad (4.5)$$

$where\ h$ is a constant which is equal to twice the rate of the description of area by the radius vector, μ is defined as the product of the gravitational constant G and sum of the masses of the Earth and the Moon $(E+m)$ while p is equal to $a(1-e^2)$, a being the semi-major axis and e the eccentricity of the orbit.

Due to solar perturbation' h' varies periodically by 0.5% in phase with 'a' Equation (4.5) may be written as:

$$\log(1-e^2) = 2\log h - \log a - \log \mu.$$

By differentiating the above equation become:

$$-\frac{2e\Delta e}{(1-e^2)} = \frac{2\Delta h}{h} - \frac{\Delta a}{a} = 0.003.$$

Since $e = 0.06443,\ \Delta e\ becomes - 0.00026$. The negative sign indicates the opposition of phase ‘a’ and ‘h ‘with the variation of 'e'. Thus the orbit becomes more elliptical at quadrature. This effect is known as the 'variation' and was discovered by Tycho Brahe in the 15th century AD. The period of this variation is also half a synodic month. In general, the eccentricity varies by ±0.0117 i.e., by ±20%. Eccentricity is the most seriously perturbed element in the periodic perturbations.

4.5. Socio-Economic, Educational Progressive and Cultural Contributions of Cultural Astronomy of Wolaita

Cultural astronomy is the study of how different cultures perceive and interpret celestial objects and events. In the Wolaita community, cultural astronomy has played a significant role in shaping the socio-economic, educational, and cultural landscape of the community.

A. Socio-Economic Contributions:

The members of the Soddo Cultural Center (Buqquraa) who participated in my FGD informed me about the element of cultural astronomy and its rhythms in the Wolaita people. They have long used it for both religious and practical applications, such as navigation and agriculture. The observations of celestial events, such as the appearance of certain stars and the phases of the Moon, have been used to determine the start of planting and harvesting seasons. This has helped to ensure that agricultural activities are carried out at the most optimal times, resulting in better crop yields and improved food security. They also used the movements of the sun, moon, and stars to understand the divine realm and the journey of the human soul after death.

According to my respondents studying and understanding cultural astronomy can have significant contributions to the social and economic development of the Wolaita community. It can help to preserve and promote their cultural heritage, promote cultural tourism, and provide insights into their traditional ecological knowledge. By understanding the Wolaita community's traditional ecological knowledge related to the sky and celestial bodies, the community can develop sustainable practices for managing their natural resources, such as agriculture and forestry, reducing the impact of climate change and mitigating natural disaster. Therefore, it is essential to promote the study of cultural astronomy in the Wolaita community and other communities worldwide.

My respondent Mr. Kuleno, added the Wolaita people's use of cultural astronomy in ceremonial and ritual practices. They celebrate the "Badhdheesaa" festival to mark the start of the rainy and planting season using Gojiliyaa. During this festival, they perform traditional dances and offer prayers for a successful harvest and rainy season. Cultural astronomy also plays a crucial role in determining the timing of the "gifaataa" or the "New Year" celebration, which takes place on the first day of the Wolaita New Year. Along with the "gifaataa" festival, the Wolaita people have a rich tradition of using stars and constellations for timekeeping. The Wolaita language has specific words for the different phases of the moon, and the position of the stars and constellations is used to determine the time of day and year.

The coordinators of Kindo Didaye Cultural Center, who were my FGD informants, added that cultural astronomy has played a role in the development of the region's tourism industry. Visitors come to experience unique cultural celebrations like "Gifaataa" and beliefs related to celestial objects. The impact of cultural astronomy can also have significant economic benefits for local communities. For example, the use of astronomy in agriculture, specifically planting and harvesting according to celestial patterns, can result in better yields and higher quality produce. This improvement can, in turn, support local farmers and increase the availability of food in the local economy.

B. Educational Progressive Contributions:

Mr. Kuleno, my respondent, added that cultural astronomy also contributes to the educational progress of the Wolaita people. It inspires a new generation of students to pursue careers in science and technology, contributing to the region's overall development. Moreover, cultural astronomy encourages children and young people to engage with science and history.

Dawit, another respondent, added that studying and understanding cultural astronomy can provide insights into the traditional knowledge and practices of the Wolaita community related to the sky and celestial bodies. This knowledge can be used to develop educational programs that incorporate traditional knowledge and practices into modern education systems. This can help to preserve and promote the cultural heritage of the Wolaita community and provide a more holistic approach to education.

C. Cultural Contributions:

In addition to the social and economic values, cultural astronomy of the Wolaita people provides additional guarantees for its common cultural goods such as calendar, agricultural activities, religions, and natural disaster management system. According to my respondents, the community's traditional beliefs and practices related to celestial objects have been passed down from generation to generation, contributing to the preservation of the region's cultural heritage. Additionally, cultural astronomy has played a role in the development of the region's art and music, with celestial objects and events serving as inspiration for traditional songs and dances.

In conclusion, our analysis suggests that through cultural astronomy practices and traditions in place within the Wolaita region have experienced transformation for betterment concerning socio-economic status along with enhanced educational opportunities besides enshrined culture mores throughout daily life for locals. These impacts have manifested via changes visible within farming techniques besides curriculums taught and adoption of traditional rituals by them. With meaningful progress continuously afoot hereabouts Wolaita; one could posit confidently state without reservation how much more transformative effects remaining possibilities could be seen through implementation further exploration into cultural astronomy.

4.6. The Challenges That Cultural Astronomy of Wolaita Faces Today and Integration of Cultural Astronomical Knowledge into the Education System

While cultural astronomy has played an important role in the culture and traditions of the Wolaita community throughout history, it faces several challenges today. Takele my respondents mentioned that the main challenge in terms of this knowledge is the loss of traditional knowledge. With the increasing influence of modernization and globalization, there is a risk of losing traditional knowledge related to cultural astronomy. Younger generations may not be as interested in learning about traditional practices and may not have the same level of knowledge as their elders. He added there is a lack of resources and funding for research and documentation of cultural astronomy practices in the Wolaita community. The traditional knowledge of cultural astronomy is often passed down through oral traditions, which can be lost over time.

Ufaysa, my informant, indicated that misunderstanding, misinterpretation, and marginalization are the challenges of this indigenous knowledge. Cultural astronomy practices of the Wolaita community are often misunderstood or marginalized by outsiders. This can lead to a lack of recognition and support for these practices. He added that there are language barriers to passing down cultural astronomical knowledge through local languages, which can make it difficult for non-native speakers to access and understand.

Mamo, my other informant, mentioned that although the community does not recognize the knowledge of heavenly bodies of sky readers, there are still those holding onto their past local knowledge of astronomy and continue to practice it. It is part and parcel of their lives, especially in their farming activities, and they depend on it for their daily life. The younger generations put no stock in this traditional way of predicting the weather by reading the sky, and to them, the information the elders convey is primitive and outdated. He added that over time, community members have come to rely less on reading the sky to manage and sustain their living conditions. This has resulted in some older members as well as the present generation stopping believing in the use of local knowledge as important for the community to sustain their lives.

The above respondent added that people are not fully aware that the culture of Wolaita astronomy is on the verge of disappearance in case the disappearance of such culture has not been studied yet. The youth do not need to show the importance of applying the knowledge and be encouraged to listen to elders when they impart it and the government should not realize and acknowledge indigenous knowledge as an important tool, especially in its benefit for sustaining rural communities with limited access to modern technology.

In the challenge of education system my respondent Bukulo, indicated that there are several challenges that may hinder the integration of cultural astronomical knowledge into the education system. One of the main challenges is the lack of recognition and support for indigenous knowledge systems in formal education. The education system often prioritizes Western scientific knowledge over traditional knowledge, which can lead to the marginalization of cultural astronomical knowledge. Another challenge is the lack of resources and funding for research and documentation of cultural astronomical practices. Without proper documentation and research, it can be difficult to integrate this knowledge into the education system in a meaningful way.

The members of the Soddo Cultural Center (Buqquraa) my FGD respondents, mentioned there may be a lack of understanding or appreciation for traditional knowledge systems, or a belief that Western scientific knowledge is superior. Language barriers can also be a challenge, as cultural astronomical knowledge is often passed down through oral traditions in local languages. This can make it difficult for non-native speakers to access and understand this knowledge.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Culture is a way of living that is typically indigenous to a specific community and has been experienced by people since the beginning of humankind. The fascination with the sky has been an important element in human life and history. The regularity of the motions of celestial objects enabled people around the world to create culturally organized systems of knowledge, known as worldviews. Generations of sky watchers carefully tracked the positions of the heavenly bodies to understand how to conduct human life on earth. Through naked eye astronomical observations, they gained practical knowledge of their natural environment from the sky.

Cultural astronomy of Wolaita is the study of the astronomical knowledge that has been present within the Wolaita community for a long time. This cultural astronomy has served various purposes, such as determining seasonal cycles, rituals, timing of daylight and dark light navigation, crop planting, mapmaking, and harvesting, as well as mating intervals. The Wolaita community follows a lunar-solar calendar that tracks the regular changes of the moon and the sun to determine the planting and harvesting seasons. Moreover, the community possesses extensive knowledge about constellations, such as the Pleiades star cluster, which helps determine the New Year's date and planting seasons.

The Wolaita people determine seasonal cycles, rituals, timing of daylight and dark light navigation, crop planting, mapmaking, harvesting, and mating intervals using the astronomical rhythms such as stars, planets, the moon, and the sun. For instance, they use three stars to determine seasonal cycles, rituals, timing of daylight and dark light navigation, crop planting, and harvesting, as well as mating intervals.

In the movement of the moon, they assign ceggennaa to use for agricultural activities, and women use the phases of ceggennaa to keep track of their menses and fertility cycles by counting from the phases of the moon. The certain moon phases and constellations can affect planting and transplanting of seedlings, as well as felling of trees, and the growth and development of plants. This is because of the moonlight reflected from the Sun and its gravitational influence. On the other hand, planet light and starlight can also affect plant development and the growth of crops.

The cultural astronomy of Wolaita is not only used for practical applications, such as agricultural activities and navigation, but it also plays a significant role in shaping the socio-economic, educational, and cultural landscape of the community. It is used to understand the divine realm and the journey of the human soul after death, using the movements of the sun, moon, and stars. Additionally, it plays a crucial role in determining the timing of the "gifaataa" or the "New Year" celebration, and it contributes to the development of the region's tourism industry. Furthermore, it contributes to educational progress by inspiring a new generation of students to pursue careers in science and technology.

However, the cultural astronomy of Wolaita faces significant challenges in the present day. One of the main issues is that the individuals possessing this vital knowledge are passing away, as it was primarily held by elderly men and women. Additionally, cultural astronomy is facing both external and internal challenges. The elders are concerned that this culture and common practice are on the verge of disappearing. The younger generation does not seem to feel responsible for preserving the culture and passing it on to the next generation. Furthermore, the expansion of Christianity, particularly Protestantism, is a major contributor to the disappearance of astronomy culture. Those who argue against it claim that people worship Sharechchuwaa or gods that represent Satan in traditional religion. However, most of the current generation, including the youth, considers this to be a myth or an ideology of the past.

5.2 Recommendations

The researchers conducted discussions with respondents and individual interviews, and experiment in certain moon cycles regarding the cultural astronomy of Wolaita and its various elements, including observation, navigation systems, prediction, myth, influence, and values. They also explored the educational, agricultural, and progressive implications of cultural astronomy and observed its role in shaping the socio-economic, educational, and cultural landscape of the community. Additionally, they examined the way of life of the Wolaita people and the influence of globalization and modernization on their culture.

Culture is a public asset that distinguishes certain people, and the Wolaita people have their own unique culture. Through their cultural practices, they express themselves and connect with one another. Among these practices, astronomical knowledge has been the most popular for a long time, binding the people together. However, this long-lived public culture is facing tremendous challenges in the present day. To preserve this culture, the researcher recommends the following points to be addressed by all responsible parties:

- The agricultural sector should be contributed to preserving agricultural practices in astronomical rhythms by educating farmers about the importance of astronomical rhythms in agriculture. Farmers should be taught how to use astronomical observations to plan their planting and harvesting schedules. Furthermore, further research should be conducted to explore the relationship between astronomical rhythms and agricultural practices in different seasons and years. This research will help farmers understand the impact of astronomical rhythms on their crops.
- Educational outreach programs should be developed for progressive implication cultural astronomy of Wolaita and whole Ethiopia to promote scientific literacy, agricultural productivity, and other forms of progress in education. The education system in Ethiopia should be developed a curriculum that incorporates cultural astronomical knowledge into different subjects, such as science, social studies, and language arts. Astronomy clubs should be established in schools and universities to promote interest in astronomy and cultural astronomy. Agricultural Workshops should be organized to educate farmers on the importance of astronomical rhythms in agriculture.
- It is also recommended that local radios can be used to disseminate the knowledge. Elders or those who hold the knowledge could be invited to talk on radio about issues of cultural astronomy and natural disaster management. Knowledge custodians should be enlightened about the danger of going to the grave with rich knowledge like indigenous knowledge.
- The government is expected to boost its effort to protect cultural practices from destruction. The government should take the initiative to invite elders, religious leaders, elites and the concerned body from the society and open discussions on ways of maintaining cultural heritages.
- The last, but not least, figures responsible to contribute in preserving culture, is scholars. They can contribute by doing researches to show where the problem is, what must be done and how scientific methods are applied in solving problems related to culture.

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APPENDIX

The topic guide will serve as a tool for conducting in-depth interviews and focus group discussions with key informants in the study area.

Introduction

Dear Respondents:

I, Temesgen Bazaw, am a prospective graduate of Masters of Science in Astrophysics at Adama Science and Technology University, School of Applied Natural Science. I am currently working on my Master's thesis on Study of Educational, Agricultural, and Progressive Implications of the Astronomical Rhythms and Celestial Objects in Wolaita Community and would like to assure you that this questionnaire is being used solely for academic purposes. Please be assured that the confidentiality of the information you provide will be respected at all times. Your honest and genuine responses to the items in this questionnaire will help to meet the objectives of this study. Thank you for your cooperation.

Thank you in advance for your support!

Appendix- A

Section 1: General Information of the Respondents

Name________________________

Age__________________________

Religion______________________ Woreda/Keble________________________

Ethnic background____________________ Marital status________________________

What is your highest level of formal education? _________________

Section 1: Interview guide for key informants of community Sky readers and other key informants including tribal chiefs, farmers, headmen, and society elders.

1. What do you know about the cultural astronomy of the Wolaita community?
2. What are elements of cultural astronomy Wolaita community uses?
3. What are some of the traditional stories or beliefs related to cultural astronomy in the Wolaita community?

4. Are there any significant celestial events in the Wolaita community that are celebrated or marked in any way, such as stars, meteor showers, planets, or comets?
5. Are there any traditional stories or myths in the Wolaita community that involve stars, constellations, or other celestial bodies?
6. Are there any notable figures or leaders in the Wolaita community who have made significant contributions to cultural astronomy?
7. What role, if any, has astronomy played in the culture or traditions of the Wolaita community throughout history?
8. Do you believe that the study and understanding of cultural astronomy can contribute to the social and economic development of the Wolaita community? If so, how?
9. What are the challenges that cultural astronomy of Wolaita faces today?

Appendix- B

Section 2: Interview guide for key informants of elders, sky readers and farmers of Wolaita community in astronomical rhythms and agricultural practices.

1. Have you ever used cultural astronomical knowledge in your agricultural practices? If yes, how?
2. What are (celestial objects) astronomical rhythms and elements of cultural astronomy that you use in in your agricultural practices?
3. How do you determine the planting dates for different crops and plants?
4. Have you ever experimented with planting crops on different lunar phases to see if it has any impact on their growth or yield?
    a) If so, are there any differences in the quality and health of crops and plants when planted at different times of the (celestial) lunar cycle?
    b) What kinds of crops and plants are believed to be most influenced by lunar rhythms?
5. Is there any difference in crop yield or plant growth when using astronomical rhythms in planting and farming compared to modern methods?
6. How does the timing of astronomical events affect the pest and disease resistance of crops and plants?
7. How does the timing of astronomical events affect the planting dates of seedlings and felling of trees?

Appendix- C

Section 3: Interview guide for key informants of agricultural officers and Development Agents (DAs)

1. Are you aware of any beliefs or traditional knowledge in your community regarding the relationship between (celestial) lunar rhythms and agricultural activities?
2. How does the Wolaita community farmer determine the planting dates for different crops and plants?
3. Have you ever experimented with planting crops on different lunar phases to see if it has any impact on their growth or yield?
   c) If so, are there any differences in the quality and health of crops and plants when planted at different times of the (celestial) lunar cycle?
   d) What kinds of crops and plants are believed to be most influenced by lunar rhythms?
4. Is there any difference in crop yield or plant growth when using lunar rhythms in planting and farming compared to modern methods?
5. Finally, in your opinion, do you believe that lunar rhythms could be used in a more scientific or systematic way as a tool to optimize crop yields in modern agriculture practices?

Appendix- D

Section 4: FGD guide questions for key FGD participants of literate of native, Cultural center (Buqquraa) members of Soddo and coordinators of Kindo Didaye

1. How do you think the knowledge of cultural astronomy can contribute to the progress of the social, educational and economic development Wolaita community and its progress?
2. Do you think there is a need for more research on the educational, agricultural, and progressive implications of the astronomical rhythms and Celestial Objects in Wolaita? If yes, why?
3. What are the challenges that may hinder the integration of cultural astronomical knowledge into the education system in Wolaita? And what do you suggest for the effective integration?

Appendix -E

Respondent of Individual in-depth interview that was held at Kindo Didaye Woreda

Mr. Alaro Ashko, tribal chiefs of Wolaita Malla clan, the resident of Kindo Didaye Woreda Gocho kebele

Mr. Ayanu Asha, Farmer, the resident of Kindo Didaye Woreda Halale kebele

Mr. Dawit Belete, members of Kindo Didaye Woreda Agriculture and Natural Resources Development Office

Mr. Mamo Gensa, a teacher at Halale Secondary and Preparatory School

Mr. Ganamo Gatiso, sky reader of Gollo Malla clan, the resident Kindo Didaye Woreda Patata keble

Mr. Tanga Balache, Farmer, the resident of Kindo Didaye Woreda Halale kebele

Mr. Wtango Bulacha, sky reader of Ayppersuwa clan, the resident Kindo Didaye Woreda Mogisa keble

Respondent of Individual in-depth interview that was held at Kindo Koysha Woreda

Mr. Ayza Bate, Farmer, the resident of Kindo Koysha woreda Sorto kebele

Mr. Banga Batire, sky reader of Aadda clan, the resident of Kindo Koysha woreda Sorto kebele

Mr. Bukulo Kasu, a teacher at Baale Secondary and Preparatory School

Mr. Halala Borsamo, Farmer, the resident of Kindo Koysha woreda Sorto kebele

Mr. Tonga Salgedo, sky reader of Wolaita Malla clan, the resident of Kindo Koysha woreda Oydu Chamma keble

Mr. Wogaso Wolde, tribal chiefs of Ayppersuwa clan, the resident of Kindo Koysha woreda Oydu Chamma keble

Respondent of Individual in-depth interview that was held at Damote Gale Woreda

Mr. Ayza Alango, elder of Gollo Malla clan, the resident of Domote Gale woreda Sebaye Karke keble

Mr. Baraka Anjulo, Farmer, the resident of Domote Gale woreda Shashe Gale keble

Mr. Godebo Kuke, tribal chiefs of Aadda clan, the resident of Domote Gale woreda Woshi Gale keble

Mr. Tanto Densa, tribal chiefs of Gollo Malla clan, the resident of Domote Gale woreda Woshi Gale keble

Mr. Zeleke Goa, Farmer, the resident of Domote Gale woreda Sebaye Karke keble

Respondent of Individual in-depth interview that was held at Boloso Sore Woreda

Mr. Adisu Tesome, Farmer, the resident of Boloso Sore woreda Yukara kebele

Mr. Ayele Koroto, elder of Gollo Malla clan, the resident of Boloso Sore woreda Dola kebele

Mr. Fanta Sado, Farmer, the resident of Boloso Sore woreda Yukara kebele

Mr. Kuleno Tuma, who is teacher of Wolaitic language at Areka Secondary and Preparatory School

Mr. Tamirat Tunta, members of Boloso Sore woredaAgriculture and Natural Resources Development Office

Mr. Tadesse Larebo, Farmer, the resident of Boloso Sore woreda Maashshido kebele

Mr. Teshome Bassa, sky reader of Wolaita Malla clan, the resident of Boloso Sore woreda Honbaa kebele

Respondent of Individual in-depth interview that was held at Boloso Bombe Woreda

Mr. Baza Utalo, Farmer, the resident of Boloso Bombe Farawocha kebele

Mr. Bantero Batimo, sky reader of Ayppersuwa clan, the resident of Boloso Bombe Ose kebele

Mr. Dawit Bunduro, members of Boloso Bombe Woreda Agriculture and Natural Resources Development Office

Mr. Gensa Tanto, Farmer, the resident of Boloso Bombe Ajora kebele

Mr. Shame Shanka, Farmer, the resident of Boloso Bombe Farawocha kebele

Mr. Wondimo Zassa, elder of Aadda clan, the resident of Boloso Bombe Ajora kebele

Appendix-F

List of respondents participated in PGD that was held with Members of Soddo cultural center (Buqquraa)

Mr. Abebe Ayza

Mr.Kasu Manjura,

Mr. Mola Wolde

Mr.Tesfaye Tomas,

List of respondents participated in PGD that was held with coordinators of Kindo Didaye Cultural Center

Mr.Abera Yigezu

Mr.Girma Worku

Mr.Ufaysa Potro