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Assessing the Effects of Climate Change on Vulnerability to Poverty: the Case of Heat Waves and Construction Workers in Egypt

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ASSESSING THE EFFECTS OF CLIMATE CHANGE ON VULNERABILITY TO POVERTY: THE CASE OF HEAT WAVES AND CONSTRUCTION WORKERS IN EGYPT

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Acknowledgment

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Abstract

"Doomsday, humanity's extinction, the end of days". Apocalyptic adjectives abound to highlight the danger looming over the planet, as the earth is warming up due to global warming and climate change. The picture painted over the canvas has consistently projected a gloomy image of low-income countries and of the poor. As the earth is gently boiling with heat, low-income groups in the Global South are predicted to be most affected. However, most of such warnings and studies focused on sectors directly dependent on suitable weather conditions such as agriculture, and sea tourism. While the climatic phenomena of heat waves may occur naturally, its increased frequency and magnitude induces Wet Bulb Temperatures (WBT), which represent the temperature of the human body under both heat and humidity. This study adopts a mixed methods approach and thoroughly dissects how increased Wet Bulb Temperature (WBT) affects the socioeconomic well-being of construction workers. The main variable of interest is the income of the construction worker. Additional data from the literature informed the addition of household food and health expenditure. The analysis reveals that increased WBT has an insignificant effect on construction workers who have a contract. However, the income of workers who are self-employed with daily targets is negatively and significantly affected by increased WBT. The analysis further shows a significant effect of WBT on households' food expenditure. These effects generate a vicious cycle trapping the construction worker in poverty and precarity. Contrary to the literature, construction workers' health in Egypt appears not to be affected by the increased WBT. Both the quantitative and qualitative data align in the same direction. Targeted interventions could contribute to breaking the vicious cycle generated by increased WBT to salvage the *gloomy* faith of the poor in the face of a boiling planet.

Chapter One: Introduction

"Climate Change is here. It is terrifying. The era of global warming has ended. The era of global boiling has arrived" António Guterres (2023)

1.1. Climate Change: The New Theat

Burning under the sun, soaked in heat, and yet, nowhere to hide as heat waves rage and warm the planet. Such is the reality of millions of low-income households and outdoor workers worldwide, particularly in Egypt, which has become, in recent years, a climate hotspot (ILO, 2019). Exposure to temperatures beyond 39 degrees can kill (ILO, 2020; Asseng et al., 2021); yet, workers involved in outdoor activities such as construction workers have no choice but to dare the risk to earn a living. Heat waves are naturally occurring climate phenomenon; however, their frequency, magnitude, and duration have increased due to climate change, thus making countries such as Egypt climatic hotbeds (Morsy & El Afandi, 2021; Duenwald et al., 2022). The increased frequency of heat waves induces Wet Bulb Temperatures (WBT), which represent the temperature of the body under both heat and humidity (Chow, 2022). High WBT decreases outdoor workers' productivity and causes heat stress, heat stroke, and death (Kjellstrom, 2009; Heidari et al., 2015; Raymond et al., 2020; Fatima et al., 2021; Gariazzo et al., 2023). As Egypt becomes a climatic hotbed, the devastating nature of heat waves and increased WBT is more apparent. In 2015, Egypt recorded between 60 to 97 deaths and hundreds of heat strokes within a week due to heat waves (APC, 2015; Daily News, 2015; Ahram Online, 2015).

Heat waves, including WBT, droughts, floodings, and long cold winters are extreme weather events to which the planet Earth and its ecosystem are naturally subjected. However, climate change increased their intensity (Morsy & El Afandi, 2021). The negative effects of such extreme weather events on human systems are known as loss and damage (Chiba et al., 2017; UNFCCC, 2012). Losses and damages vary based on geographical location, economic development, socioeconomic groups, economic sector, and type of revenue-generating activities (Eckstein et al., 2021; Bellon & Massetti, 2022; Ullah et al., 2017; Islam & Winkel, 2019). On a global scale, losses and damages vary as extreme weather events disproportionately affect developing countries compared to developed ones (Eckstein et al., 2021). While developed countries may record more economic damage, developing countries may witness more life and livelihood loss (Dow, 1992; Bellon & Massetti, 2022). Within the same country, losses and damages vary across socioeconomic groups and areas (Ullah et al., 2017). While extreme weather events may affect agriculture and livelihoods in rural communities, they increase food inflation in urban communities (Waha et al., 2017). Outdoor workers in construction, agriculture, and refuse collection are disproportionately affected by extreme weather events compared to office workers (ILO, 2019). Losses and damages among precarious workers include malnutrition, poor health outcomes, and loss in productivity and income (Chiba et al., 2017; Raymond et al., 2020; Narocki, 2021; Das, 2015). The foregoing illustrates that countries, individuals, and economic sectors subject to the same weather extremes are affected differently.

Extant literature establishes the variation of losses and damages may exacerbate inequality among countries (Bellon & Massetti, IPCC, 2022; Islam & Winkel, 2019). Such literature raises macroeconomic issues such as GDP growth, infrastructure, and job creation challenges that may arise due to extreme events (Waha et al., 2017). While developed countries may have the means to rebuild after extreme weather events, and resume growth-generating activities, developing countries may struggle to bounce back from weather extremes, further worsening their ability to face upcoming extreme events, thus remaining trapped in a vicious circle of underdevelopment (Stern, 2007; Bellon & Massetti, 2022).

Researchers also highlighted within-country inequality, arguing that weather extremes would exacerbate poverty and widen the inequality gap between high and low-income groups (Robinson et al., 2012; Waha et al., 2017; Chiba et al., 2017, World Bank, 2014). However, such studies often contain "*general statements*," providing limited explanations on exactly how extreme weather events could exacerbate poverty among low-income households (Islam & Winkel, 2019). The few research with case studies explaining the relationship between climate extremes, poverty, and inequality focused on rural areas or households and economic activities involved in climate-dependent sectors (Stern, 2007; Wodon et al., 2014; Islam & Winkel, 2019).

In Egypt, studies explaining how extreme weather events could affect citizens and economic development often focused on rural areas where most households depend on agriculture or sectors such as tourism in cities directly impacted by the climate (El-Raey et al., 1999; El-Nahry & Doluschitz, 2009; Stimson Center, 2010). Such studies provide data for policymaking; however, a literature gap arises regarding the effect of weather extremes on economic sectors not directly dependent on the climate. How do weather extremes exacerbate poverty and inequality in sectors, unlike agriculture, which are not directly climate-dependent but contain precarious and low-income workers? How do weather extremes exacerbate urban poverty among low-income households in urban areas involved in non-climate-dependent activities?

Urban poor and precarious workers are mainly in the informal economy which accounts for 85.8% of jobs in Africa (OECD/ILO, 2019). About two-thirds of the working population in Egypt are precarious workers (Fedi et al., 2019). Although precarious work is highest in rural areas (69.7%) compared to urban areas (60.5%) in Egypt, work precarity increased faster in urban than rural areas (Fedi et al., 2019). The rising trend of informality is a critical source of concern in analyzing poverty in Egypt (World Bank, 2023).

Outdoor workers, particularly construction workers, most of whom are precarious workers, are vulnerable to heat waves and WBT (ILO, 2019; Raymond et al., 2020). In Egypt, the economy is increasingly moving from agriculture to construction, with 90% of jobs in construction being precarious (Fedi et al., 2019). While analyzing poverty in Egypt requires special attention to precarious workers, the economic activity shift towards the construction industry stimulates special interest in research and policy. Studying the effects of extreme weather events on precarious workers, particularly in the construction industry, is considered a priority given the high level of precariousness in the sector and the likelihood of occupational hazards (Rowlinson et al., 2014). Against this background, this research investigates the effects of extreme weather events on the socio-economic well-being of construction workers in Egypt.

1.2. Research Objectives and Policy Relevance

"***For, there will never cease to be poor in the land; that is why I am commanding you to open wide your hand to your brother and to the poor and the needy in your land***" (Deuteronomy 15:11, Jewish Torah, 1312 BCE).

Such was the command of the Lord passed down to Moses in Mont Sinai in Egypt. Indeed, the poor have not ceased to exist, no matter how wide we open our hands. Over the years, Egypt, the blessed land, has been plagued by poverty. However, just as the world failed to make poverty history (Hanlon et al., 2010), the number of poor in Egypt has increased over the centuries (World Bank, 2023; Abu Hatab, 2019).

Social policies seek to provide a net allowing citizens to improve their socio-economic well-being and are meant to protect low-income families from shocks that may negatively affect their livelihoods or welfare (Schuring & Loewe, 2021). Extreme weather events are environmental shocks threatening the socio-economic well-being of citizens. Thus, it is critical to understand its contours to inform effective policy design. Understanding how climate change affects different socio-economic groups is critical to reducing its impact on communities (Chiba et al., 2017) and improving planning for policy actions and resource allocation (Zhou et al., 2022; Su et al., 2022). While social policy represents a way of opening our hands, as per the Torah, we ought to understand the factors making the people poor to guide how and when we open up to them.

Poverty remains a contributing factor to rural exodus and the sprawling informal settlements in Cairo, known as “Ashawiy’aat” (Shawkat, 2020). Researchers observed a vicious cycle between climate change and rural exodus (Wodon et al., 2014). Residents of informal settlements are of particular interest since they constitute the majority of the urban poor in Cairo and are particularly vulnerable to extreme weather events (UNDP, 2007). An aspect of socioeconomic well-being involves dwelling type. While poverty may constitute an overarching issue, extreme weather events may constitute a new stressor contributing to the growth and sustenance of informal settlements in Cairo. Understanding how extreme weather events affect precarious workers and designing effective social policies to protect and promote the well-being of the urban working poor, the majority of whom reside in informal settlements, could improve their income and financial power and enable them to move to safer areas. Furthermore, this approach would support the government's efforts in addressing inclusive development and contribute to achieving Sustainable Development Goal (SDG) 11 on sustainable cities.

The issue of environmental and climate justice is a growing debate in the international community. Data suggests that countries such as Egypt contribute the least to Greenhouse Gas (GHG) emissions and yet suffer the most from the consequences of climate-induced weather extremes. The debate has led to the creation of a Loss and Damage Fund to which developed countries should contribute financially to support social policies towards alleviating the impact of extreme weather events in developing countries and vulnerable populations. It is critical to understand how the working poor in different sectors are affected and what are the exact losses and damages recorded by these groups at the micro level. Such understandings would inform tailored policies, for example, on cash transfers as a form of compensation.

The policy relevance of this study feeds into my main objective, which is to understand in what ways climate change, which is manifest through extreme weather events, affects different socioeconomic groups. This research seeks to understand *if* and *how* climate events may contribute to poverty. My analysis study focuses on construction workers, most of whom are precarious urban working poor (ILO, 2019; Fedi et al., 2019). Existing literature established construction workers' vulnerability to income loss, and poor health outcomes due to WBT Chiba et al., 2017; Raymond et al., 2020; Narocki, 2021; Das, 2015). Consequently, this study will seek to capture the effects of WBT on income and health outcomes among construction workers.

1.3. Problem Statement

A critical issue in the MENA remains a knowledge gap in terms of research on climate change-related issues in the built environment (Dabaieh et al., 2022) although the region is a climate hotspot (Duenwald et al., 2022). Honing in on Egypt, research efforts studying climate change and its impact on citizens focused on populations reliant on natural resources in climate-dependent sectors such as agriculture, and tourism in coastal areas or activities affected by Sea Level Rise (SLR), and water availability (El-Nahry & Doluschitz, 2009; Stimson Center, 2010; Wodon et al., 2014; Abutaleb et al., 2015; Ahmed, 2018; Mohamed, 2018; UNDP/MPED, 2021; Barakat et al., 2022). Other studies investigated climate governance in the private sector (Shaheen, 2023) and among civil society and governmental institutions (El Baradei, 2023; El Baradei & Sabbah, 2023). While we know how high WBT affects the socioeconomic well-being of urban poor and construction workers in Europe and Asia (Das, 2015; Venugopal et al. 2016; Orlov et al., 2019; Nizam et al., 2021), in the MENA region, in Egypt, little is known about how exactly high WBT affects the income, food, and health expenditures of construction workers (Dabaieh et al., 2022). Thus, conducting research on precarious workers in an urban area would contribute to filling a knowledge gap.

Several statements stress the potential for climate change to worsen poverty and inequality, particularly among developing countries (Robinson et al., 2012; World Bank, 2014; Waha et al., 2017; Ullah et al., 2017; IPCC, 2022). However, most of such statements are either general (Islam & Winkel, 2019) or concerned with climate-dependent sectors such as agriculture. The argument sustains that climate change contributes to reducing water availability, thus affecting crop yields and reducing farmers' livelihoods (Stern, 2007). What of citizens not involved in climate-dependent sectors? How does climate change contribute to poverty among such groups? Moreover, how does climate change lock these groups in a perpetual poverty trap? A particular concern of this study lies with construction workers who are precarious working poor urban dwellers. While there are studies on how extreme weather events affect the health and productivity of construction workers in Egypt (El-Shafei et al., 2018; ILO, 2019), to the best of my knowledge, there is no study assessing the social and economic effects of extreme weather events on construction workers despite the relevance of the industry for the economy.

1.4. Study Contribution

This study proposes a new methodological approach to capturing the impacts of climate change. While I am particularly interested in the heat variable and the phenomenon of Wet Bulb Temperature (WBT), the methodological approach I add to the literature would contribute to analyzing the effect of other extreme weather events on different socioeconomic groups, particularly seasonal workers with irregular income streams. Studies analyzing the impacts of Heat waves and WBT on construction workers adopted mainly two methods. Either through microanalysis by conducting surveys and interviews during the summer when construction workers are engaged in their activities (Das, 2015; Venugopal et al. 2016) or by adopting a macro-analysis through industry data and analyzing annual work output (Orlov et al., 2019; Nizam et al., 2021). Such approaches often focus on the construction worker as a unit of analysis. While they provide critical data, most poverty alleviation programs in developing countries are designed to target households and rarely the individual unless cases of physical incapacity like the Karama program in Egypt. Furthermore, poverty alleviation programs in the form of cash transfer programs are based on Proxy Means Testing (PMT), which captures household-level assets and socio-economic factors. While understanding a worker's context as a unit is important, this study proposes approaching the matter with a household as the unit of analysis to facilitate the design of social programs. Considering the household as the unit of analysis further helps in infusing econometric models with factors such as dwelling type, access to infrastructure and public services, and household characteristics.

Another key contribution to the literature is the study design. Although in this research I use household data through quantitative analysis, I also conducted interviews. To the best of my knowledge, no other study using datasets to estimate the effect of WBT on construction workers adopted such an approach. The use of datasets expands the scope of the study to the national level while conducting interviews helps capture qualitative data to posit strong context relevant policy recommendations.

1.5. Research Questions

Through a thorough excavation of both quantitative and qualitative data, this research investigates the effect of climate change on the socioeconomic well-being of construction workers. Wet Bulb Temperature (WBT) which is induced by heat waves is a climatic phenomenon that affects outdoor workers' productivity, and health outcomes. Therefore, this research focuses on Wet Bulb Temperature (WBT) as a climate stressor. In the study, I test several hypotheses and show the relationship between different elements to understand in what ways climate change locks the poor in poverty. The main research question is: **How do extreme weather events affect the socioeconomic well-being of construction workers in Egypt?**

The study will seek to answer the research question through a set of sub-questions:

- How does Wet Bulb Temperature contribute to wage loss among construction workers' households in Egypt?
- How does Wet Bulb Temperature affect food expenditure among construction workers' households in Egypt?
- How does Wet Bulb Temperature affect health expenditure among construction workers' households in Egypt?

1.6. Outline of the Thesis

The hereby study is divided into six chapters as follows:

Chapter One introduces the study's motivation, including its background. The chapter further reveals the study's relevance to the policy landscape and its contribution to the growing body of literature on the impacts of climate change on poverty and inequality, particularly in the built environment.

Chapter Two dives into the literature to highlight previous studies conducted on climate change. The literature builds from the history of climate change, starting from ancient Greeks to contemporary times, and how humans' understandings evolved. The second part of the literature highlights studies on the impact of climate change on human societies and different socio-economic groups. The literature ends with an exploration of climate change studies in Egypt and the identification of the literature gap.

Chapter Three provides a contextual framework by embedding the issue of climate change within the socioeconomic and political context in Egypt.

Chapter Four leverages the literature and presents the study's methodology, including the conceptual framework and key terms operationalization, the quantitative model construction, and the design of the qualitative aspect.

Chapter Five consists of findings and discussion.

Chapter Six concludes the study with policy recommendations and the study's limitations.

Chapter Two: Literature Review

"*The scientific research must capture details, analyze, and discover internal relations between the various elements of the matter, the subject being studied*" Henri Lefebvre (2012).

It is critical to situate the research problem within a relevant body of literature and analyze the internal relationships between different variables related to climate change and its impact on human societies. Therefore, this review of the literature highlights other studies and findings and identifies the contribution of this research to the body of knowledge on climate change and its impacts on the socioeconomic wellbeing of low-income households. This review is divided into three main parts: *i)* Extreme weather events and their effects on poverty and inequality including workers' wages, expenditures, health outcomes, and socioeconomic well-being; *ii)* Climate Change and construction workers in Egypt; *iii)* the literature gap and study contribution. I conducted these analyses across countries worldwide and then in the Egyptian context.

2.1. Climate Change and Extreme Weather Events

Global warming is the long-term gradual warming of the earth's temperature (Weart, 2009). Originally, the earth's temperature is balanced due to the greenhouse effect (Adedeji et al., 2014; Kweku et al., 2017; Adamo et al., 2021). The greenhouse effect is a two-part naturally occurring phenomenon. First, the sun radiates sunlight, which warms the Earth. Then the earth absorbs the needed amount of heat from the sunlight to balance temperature, and then in a second part the earth radiates back to outer space the remaining extra heat not needed (Sagan, 1985; Kweku et al., 2017; Adamo et al., 2021). This two-part process, known as the greenhouse effect, keeps the earth's temperature balanced for human life. However, gases such as Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), etc. (Adedeji et al., 2014) emitted by burning fossil fuels such as coal, oil, and natural gas, trap on Earth the extra heat which is supposed to be radiated (Sagan, 1985). While sunlight is heating the planet, the earth cannot radiate the extra heat it does not need back to outer space. By trapping the heat on Earth, the planet gradually warms up and leads to what we call "*global warming*" (Stott, 2016; Kweku et al., 2017; Adamo et al., 2021).

The intensive use of fossil fuels increased the quantity of gas in the atmosphere and deregulated the natural warming process (IPCC, 2021). In 2019, Carbon dioxide (CO_2) concentration in the atmosphere was higher than in the past 2 million years. Methane (CH_4) and nitrous Oxide (N_2O) concentrations in the atmosphere were higher than 800,000 years ago (IPCC, 2021). Since 1880, the Earth's temperature has risen by 0.14° Fahrenheit (0.08°Celsius) per decade, and in 2021, surface temperature across land and ocean was 1.51°F (0.84°Celsius) warmer than the twentieth-century average (NOAA, 2022).

Since the temperature on earth is warming, it has deregulated the normal weather pattern, inducing changes in rain patterns and temperature. Such changes are referred to as climate change (Adedeji et al., 2014). Climate change is difficult to explain (Ornes, 2018); however, it is expressed and experienced by humans through extreme weather events (Otto, 2019). Extreme weather events include Heat waves, droughts, long cold winters, frequent storms, and extreme precipitations (NASEM, 2016). They are manifest when the weather at a point in time is above or below the known and average threshold (Stephenson, 2008; WMO, 2024). Therefore, when the temperature is extremely above the observable threshold at a specific location, it is referred to as a heat wave, while extremely low temperatures at a specific location are cold waves. The weather is extreme when, at a point, the weather is different from the average observable patterns (Radović & Iglesias, 2019). This conceptualization applies to precipitations, storms, ice storms, cyclones, etc. Extreme weather events vary from one location to the other based on the average weather in a specific place. Thus, extreme temperatures in Europe may be average temperatures in Africa. When extreme weather events become constant, they are referred to as extreme climate events (IPCC, 2014).

Extreme weather and climate events may occur naturally but are rare and short-term (Otto, 2019; Van Aalst, 2006); however, with the phenomenon of global warming and climate change, their frequency, intensity, and magnitude have increased (Nicholls et al., 2012; Adedeji et al., 2014; Stott, 2016; Chiba et al., 2017; Ornes, 2018; Otto, 2019; Morsy & El Afandi, 2021; Duenwald et al., 2022). For example, in 2022, Pakistan recorded in August an excess of 243% more rainfall than the average over 30 years (Pakistan Meteorological Department, 2022).

Extreme weather events may also cause extreme conditions. For example, extreme precipitation causes flooding, extreme warming causes sea level rise. Heat waves may cause Wet Bulb Temperatures (WBT), which capture the temperature of the human body under both heat and humidity (Chow, 2022). It is also referred to as extreme humid heat or Global Wet Bulb Temperature (GWBT) (Budd, 2008; Raymond et al., 2020). WBT is based on the premise that when the weather is hot, the body releases sweat. When the sweat evaporates, the human body cools off (Budd, 2008). The appearance of the sweat humidifies the body. WBT measures the heat of the body when sweating under extreme heat (Chow, 2022). When the WBT is high, it means that the sweat is not evaporating fast. This condenses heat in the human body and causes heat stress, heat stroke, dizziness, and potentially death. Increased WBT is traced to climate change and heat waves (Budd, 2008; Kjellstrom et al., 2016; Raymond et al., 2020).

Early efforts on the impact of climate change and extreme weather events focused on understanding why the ice age disappeared (Dow, 1992; Le Treut et al., 2007; Carey, 2010;

Islam & Winkel, 2019). Later, studies turned to the effect of the melting ice sheet in Antarctica on polar bears, their habitat, species distribution, and extinction (Stirling & Parkinson, 2006; Guisan & Thuiller, 2007). Early efforts towards the impact of climate change on humans include the Christian Aid 2007 “goat man” campaign and the 2009 tagline “climate change threatens more than just polar bears and ice caps.” (Manzo, 2010). Ever since, the discussion moved to focus on human welfare, particularly the issue of poverty in developing countries, and sparked the debate over climate-induced loss and damage. This study is interested in extreme weather events, particularly heat waves and the WBT.

2.2. Extreme Weather Events and Poverty

Poverty is conceptualized into an individual’s state in which they cannot address their basic needs and suffer from several disadvantages including poor health and malnutrition, low quality of work and education, limited accessibility to services including water and electricity (Multidimensional Poverty Peer Network, 2020). It is assumed that increased poverty is one of the negative consequences of climate change particularly among developing countries (Stern, 2007). The negative effects of extreme weather events on human societies are referred to as Loss and Damage (L&D) (UNFCCC, 2012; Chiba et al., 2017; Eckstein et al., 2021), including the disruption in individuals’ and communities’ way of life (Page & Heyward, 2017). Loss refers to what cannot be recovered, and damage encompasses what could be restored after an extreme weather event (UNFCCC, 2012). Loss and Damage (L&D) was introduced in the discussion on climate change in 1991 (UCS, 2023); however, the term reappeared more prominently in 2007 in the United Nations (UN) proceedings. In 2013, the term gained much prominence with the increasing need to address the adverse effects of extreme events on developing countries and vulnerable populations. This led to the establishment of the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (WIM) (UNFCC, 2013). Loss and Damage re-emerged strongly in 2022 during the Conference of Parties 27 (COP27) with the establishment of the Loss and Damage Fund to support developing countries most affected by the adverse effects of climate change (Liao et al., 2022).

There are two types of loss and damage: Economic Loss and Damage (ELD) and Non-Economic Loss and Damage (NELD) (Serdecznya et al., 2017; Chiba et al., 2017; Page & Heyward, 2017). ELDs refer to losses and damages with a market value that can be quantified (Chiba et al., 2017). ELD includes infrastructure damage, loss of housing, loss of livelihood, etc. These can be quantified. NELDs are losses and damages that cannot be traded in markets; however, they are essential These include the loss of biodiversity, cultural heritage, and social relationships due to climate migration (Chiba et al., 2017).

Extreme weather events are set to increase Economic Loss and Damage (ELD) on households' livelihoods, income, and expenditure and widen inequality and poverty among developing countries (Robinson et al., 2012; World Bank, 2014; Waha et al., 2017; Ullah et al., 2017; IPCC, 2022). Other losses include loss of life, malnutrition, and health issues (Chiba et al., 2017). One of the first works considering poverty within the climate equation is the Stern Report (2007), which analyses the impact of climate change on economic growth. The report highlights the relationship between climate change and decreased water supply, which affects agriculture and, subsequently, the livelihoods of rural communities, economic growth. The Stern report (2007) highlights that climate change could lock communities in poverty:

"*Strategies to manage the risks and impacts of an adverse climate can lock people into long-term poverty traps. The survival strategies adopted by poor people to cope with a changing climate* *may damage their long-term prospects. Equally, if there is a risk of more frequent extreme weather events, then households may also have shorter periods in which to recover, thus increasing the possibility of being pushed into a poverty trap.*" (The Stern report, 2007, p101)

Another study includes the 2007 Human Development Report (UNDP, 2007), which highlights how climate change would affect the poor. Rural areas are to record more income and asset loss since they have limited administrative and infrastructural facilities to meet their needs (Ullah et al., 2017) and have limited options for income-generating activities often centered on agriculture, which is climate-dependent (Zhou et al., 2022; Ullah et al., 2017). Meanwhile, urban areas, including formal and informal metropolitan areas (Zhou et al., 2022), feature social, infrastructure, and administrative functions to meet residents' needs (Su et al., 2022), however, they may be vulnerable to flooding, particularly in informal settlements (UNDP, 2007).

Loss and damage as a result of extreme weather events vary from one area to the other depending on infrastructure development, economic growth, and citizens' sources of income (Su et al., 2022; Zhou et al., 2022) natural weather, land surface, and external drivers (Otto, 2019). In South Africa, for example, rural areas are more exposed to droughts, while urban areas are more exposed to floods (Zhou et al., 2022). Rural areas are also affected by livelihood loss, mainly agriculture (Wodon et al., 2014). The negative impact on agriculture also results in food inflation, which affects urban dwellers most (Waha et al., 2017). This generates inflation, affects citizens' income and savings, and economic development, thus poverty (Robinson et al., 2012).

As extreme weather events exacerbate the incidence of poverty, it is also set to increase inequality between developed and developing countries, between the rich and the poor, and between men and women or boy child and girl child (IPCC, 2022; Robinson et al., 2012; Waha et al., 2017; Ullah et al., 2017; Chiba et al., 2017; World Bank, 2014; Bellon & Massetti, 2022;

IPCC, 2022). Climate change-induced inequality is mainly based on the level of exposure and the ability of households to cope when affected by an extreme event (Islam & Winkel, 2019).

Developing countries are more exposed and vulnerable to climate change given their heavy reliance on agriculture for income; thus, when affected by climate extremes, their losses and damages are higher compared to developed countries, which may have diversified sources of revenues (Stern, 2007; Eckstein et al., 2021). This reality is further translated within countries and households. Thus, countries, communities, and households subjected to the same climate event may be impacted differently (Ullah et al., 2017). While in rural areas, the sources of livelihoods hovers around agriculture, which is climate dependent, rural citizens are more vulnerable to climate change compared to urban citizens (Waha et al., 2017). The disproportionality in vulnerability and source of income may lock in poverty a group, while others can build back and resume well-being-improving activities swiftly, thus increasing inequality (Stern, 2007; Bellon & Massetti, 2022). In urban areas, citizens in informal settlements may also be more vulnerable to floods than those in residential areas and may remain locked in a cycle of poverty as they have less time to build back after a disaster before the next one (Stern, 2007; Islam & Winkel, 2019). This may increase urban inequality.

2.3.1. Extreme Weather Events and Poverty in Egypt

In Egypt, extreme weather events are new stressors set to worsen poverty and inequality, particularly among low-income households considered vulnerable (Wodon et al., 2014; Waha et al., 2017; Ullah et al., 2017; Chiba et al., 2017) and disproportionately impact precarious workers (ILO, 2019). Agriculture remains one of the most sensitive sectors to climate change in Egypt. Climate change is set to affect water availability and crop yield, thus affecting the livelihoods of rural inhabitants and generating food inflation, which is set to affect expenditure among urban dwellers and increase malnutrition (Stern, 2007; UNDP/MPED, 2021; Barakat et al., 2022). Data suggests climate change would result in reducing the yield of wheat, rice, and corn by 15%, 11%, and 14%, respectively (UNDP/MPED, 2021).

Extreme weather events vary across different governorates. Urban areas such as Alexandria, Port Said, and The Nile Delta are affected by sea level rise (El-Nahry & Doluschitz, 2009; Stimson Center, 2010) as a result of global warming. Other studies identified that urban areas such as Port Said, Cairo, and Asyut are prone to flash floods (Stimson Center, 2010; Mohamed, 2021). Researchers also identified in the Suez Governorate and Cairo the phenomenon of Urban Heat Island (UHI) (Ahmed, 2018; Abutaleb et al., 2015).

The variation in extreme events induces a variation in Loss and Damage (L&D). While Sea Level Rise (SLR) in Alexandria and Port Said are susceptible to causing a loss of 30 percent of the land and jobs due to inundation (El-Raey et al., 1999), the Nile Delta would record an increase in water and land salinity thus affecting agriculture (El-Nahry & Doluschitz, 2009). In terms of economic activity, while in Port Said and Alexandria, the job losses are in tourism in the Nile Delta, the job losses are in Agriculture (El-Raey et al., 1999; Stimson Center, 2010). While studies in Egypt have clearly outlined the effect of the changing climate on agriculture and tourism, how about precarious construction workers? While the literature highlights the impact of climate change on human systems, there remains the use of uncertainty. The Stern (2007) report, for example, uses in several instances words such as “Likely,” “could,” and “*may*” and suggests several assumptions. Though the report analysis is logical, it may suggest high uncertainty. According to Islam and Winkel (2019), while the discussion on the impact of climate change on human systems may remain legitimate, it consists of a “*general statement*”.

Furthermore, most of the studies analyzing the effects of extreme weather events on human systems, particularly in developing countries, heavily focused on agriculture, water availability, scarcity of natural resources, sea rise level, and their impact on poverty and inequality (Stern, 2007; Ullah et al., 2017; Eckstein et al., 2021).

2.4. Wet Bulb Temperature (WBT), and Precarious Workers

2.4.1. Precarious Workers

Globalization, new competition to U.S. trade, new technologies, and the declining economic boom in the USA fueled the disappearance of stable industrial jobs and the emergence of low-wage, casual/temporary employment (Kalleberg, 2011). In the 1980s, while Germany recorded high unemployment rates, by the late 2000s, employment improved, characterized by low wages, working poverty, and casual employment (Brady & Biegert, 2017). In Europe, neoliberal policies favored changes in the labor market with more “flexibility” in hiring and firing workers, part-time, and temporary contracts through employment/contracting agencies/intermediaries (Kalleberg, 2000). As globalization and neoliberal policies rose, job precarity became part of life and could be found in the public and private sectors (Bourdieu, 1997; Kalleberg, 2011; Arnold & Bongiovi, 2013). The 2008 economic crisis further affected job quality and fueled the resurgence of “precarious and insecure work” (Hewison, 2016). In discussing precarious jobs, Bauman (2000) highlights the following:

> “The French theorists speak of *précarité*, the German of *Unsicherheit* and *Risikogesellschaft*, the Italians of *incertezza* and the English of *insecurity* … The phenomenon that all these concepts try to grasp and articulate is the combined experience of *insecurity* (of position, entitlements, and livelihood), of *uncertainty* (as to their continuation and future stability), and of unsafety (of one's

body, one's self and their extensions: possessions, neighborhood, community)" (Bauman; 2000; p160)

Over the years, the lexicon of precarious work has evolved and now includes terms such as "informalization, casualization, contractualization, flexibilization, nonstandard, irregular, and contingent employment" (Arnold & Bongiovi, 2013). Precarious work is often non-standard employment, including temporary or part-time jobs involving high job insecurity, low wages, and limited control of employees over working conditions (Campbell & Price, 2016; Gunn et al., 2021). Precarious workers are often excluded from their employers' health insurance, sick pay, and social security plans and are to bear risks from their employment (ILO, 2012). Precarious employment results in precarity beyond the job (Campbell & Price, 2016) and contributes to housing, welfare, and social insecurities (Bourdieu, 1997; Bauman, 2000; Anderson, 2010).

While precarious employment is highly associated with the informal sector in developed countries, in the global South, the informal economy constitutes the real economy (Lee & Kofman, 2012; Rogan et al., 2017). When discussing work conditions in the global south, it is critical to identify the type of jobs rather than comparing the formal and informal sectors (Fields, 2020). Employers, regular informal wage workers, and own account operators, including consultants, record-high average earnings and low risk of poverty, while informal, casual workers, homeworkers, and unpaid family workers are more at risk of poverty (Rogan et al., 2017). This conceptualization suggests that individuals could work in the informal economy, with temporal contracts, but not experience precarity. In this study, however, we are concerned with precarious employment. This concerns workers in non-standard employment, such as those in the construction industry, often experiencing high job insecurity, low wages, and limited control over working conditions. Precarious employment is rising in Africa, with workers disproportionately affected by climate change (ILO, 2019).

2.4.2. Wet Bulb Temperature (WBT) and Construction Workers

Although there are several climate and weather extremes, heat waves are the deadliest (Marshall, 2022; WWA, 2023), particularly through the phenomenon of WBT (Kjellstrom, 2009; Raymond et al., 2020) and have been the subject of several studies, particularly on health impacts among precarious workers (Rowlinson et al., 2014; ILO, 2019; Narocki, 2021). Heat waves induced WBT decrease productivity among precarious workers and increase the likelihood of heatstroke, dehydration, or death (IPCC, 2014; Kjellstrom et al., 2016; Narocki, 2021; Fatima et al., 2021; Gariazzo et al., 2023). Exposure and productivity during high WBT vary across precarious workers (Acevedo et al., 2018; Narocki, 2021).

"*The effects of rising average temperatures are felt differently across occupations and employment sectors. For example, jobs involving high levels of physical exertion or prolonged work outdoors are particularly affected by increasing heat levels. Agricultural and construction workers are expected to be the worst affected.*" (ILO, 2019, p14)

Gulf countries are located in one of the world's hottest region and outdoor workers are particularly affected by increasing temperatures (Ali, 2022). Although in Qatar, the United Arab Emirates, Bahrain, Kuwait, and Saudi Arabia governments adopted policies for construction workers to stop work between 12 - 3 pm on average, the policies are yet to record full compliance and are not effective in protecting workers from the dangers of increased Wet Bulb Temperature (Al-Bouwarthan et al., 2019; Human Rights Watch, 2023). A review by (Acharya et al., 2018) identified that some migrant construction workers in Qatar, the United Arab Emirates (UAE), and other middle eastern countries work even during mid-day when heat is at its highest and this has resulted into deaths, and heart attacks. In Saudi Arabia, Al-Bouwarthan et al., (2019) further identified that even when construction workers stop work at mid-day (from 12 to 3 pm) they remain excessively vulnerable to heat stress. Research by Vital Signs, (2022) identified that about 10 000 migrant workers, including in the construction industry die every year with heat and humidity as one of the main causes of death.

Studies in Australia, Canada, China, Italy, Spain, and the USA highlighted the potential of extreme heat to increase occupational injuries (Fatima et al., 2021), particularly among construction workers operating hand-held tools (Gariazzo et al., 2023). Among developing countries that already experience a hot climate, productivity among outdoor workers is set to decrease when the temperature reaches 30 degrees (Kjellstrom et al., 2009). Nizam et (al., 2021) quantified the productivity variations and identified that heat waves reduce workers' productivity by 48%, particularly among construction workers, given the nature of their work, which requires high exposure to heat and the intense use of muscles.

Macroeconomic studies by Orlov et al., 2019 sought to study how increased WBT in Europe affected productivity and income loss in construction and agriculture. The researchers quantified the reduction of work output, value-added, the value of production, gross wages reduction, the impact of tax loss, and the social burden of tax loss from the reduced economic output in construction and agriculture. Orlov et al., 2019 used the GTAP datasets of 2004 to be compared to those of 2003 and the 2011 datasets to be compared to those of 2010 and 2015. The researchers recorded the economic loss per worker in agriculture amounted to USD 59 - 90 and in construction USD 41-72. While Orlov et al. (2019) provided critical insight, their study is based on macroeconomic data at the country level, which may not always reflect the realities on the ground. Orlov et al. (2019) assume that income loss affects tax collection; however, while tax collection is important for social expenditure, there may not always be a correlation between tax collected, increased social expenditure, and social well-being.

In an effort to assess the monetary cost of heat waves on informal workers in Bhubaneswar and Sambalpur in India, Das (2015) carried out a survey during the 2013 summer involving 150 precarious workers across 10 sectors, including vegetable sellers, cobblers, taxi and auto drivers, construction workers, etc. Through the survey and quantitative analysis, Das (2015) recorded that precarious worker adaptation expenditure (purchase of fan) through loans and savings increased, over 50% of income was used for food and water purchases as adaptation strategies, and lost 24% of their income due to increased resting time.

In another study, Venugopal et al. (2016) focused only on the impact of heat stress on migrant construction workers in Southern India (90% of construction workers are internal migrants). The researchers administered their survey to 142 construction workers in five construction sites while work was ongoing under a specifically measured temperature. The study recorded decreased productivity and increased illness among workers, which may lead to absenteeism and wage loss. The social impact recorded included less time spent with children and uncertainty about job availability due to frequent illness, and family disputes.

A critical aspect of the effect of heat stress among outdoor workers remains wage loss due to decreased productivity, particularly among workers with daily targets paid based on outputs (Venugopal et al., 2016; Narocki, 2021).

> "*Excessive workplace heat is a well-known occupational health and productivity danger: high body temperature or dehydration causes heat exhaustion, heat stroke, and in extreme cases, death. A worker's natural protection is to slow down work or limit working hours, which reduces productivity, economic output, pay, and family income*" (Kjellstrom et al., 2016, p3).

As precarious workers, including those in the construction industry, are more and more exposed to heat waves and increased wet bulb temperatures, they record wage loss, are likely to witness increased health expenditure and forgo social activities which are likely to disrupt their social comfort (Stern, 2007; Anderson, 2010; Nunfam et al., 2019). Highly exposed precarious workers are also highly exposed outside working hours due to inadequate housing (Anderson, 2010), lack of air conditioners, and poor ventilation, further exposing them to health risks likely to decrease their income, further reducing their ability to move throughout the social ladder and resulting in higher social inequality (Nunfam et al., 2019; Narocki, 2021). These effects may limit national economic growth in the long term (García-León et al., 2021; Kjellstrom et al., 2016).

2.4.3. Wet Bulb Temperature (WBT) and Construction Workers in Egypt

In 2015, Egypt recorded between 60 to 97 deaths and hundreds of heat strokes within a week due to heat waves (APC, 2015; Daily News, 2015; Ahram Online, 2015). Although Egypt is subjected to hot weather during summer, studies have highlighted that the increase in intensity and frequency of heat waves have proven lethal due to wet bulb temperatures, which cause heat stress, which occurs when the heat surrounding an individual is higher than the body can bear (Rowlinson et al., 2014; Kjellstrom et al., 2016; Narocki, 2021 ECESA, 2023).

Over the past decades, data suggests a growing rate of informal employment in Egypt, from 24% in 2006 to 39% in 2018 (Assaad et al., 2019; World Bank, 2023). Construction workers, particularly bricklayers and stonemasons, are among the top three blue-collar professions, having recorded the highest percentage of real wage between 2015 and 2019 (Hendy & Hassan, 2023). Such findings may be justified by the growing shift of the Egyptian economy from Agriculture to the Construction industry, of which 90% of jobs are precarious (Fedi et al., 2019).

Precarious workers, including those in the construction industry, remain vulnerable to extreme temperatures in Egypt (ILO, 2019). Furthermore, El-Shafei et al., (2018) in their study recorded health issues among construction workers as a result of heat waves, including dizziness, muscle pain, etc. Given the rise of precarious work, particularly in the construction industry, and the heat waves in Egypt, the International Labor Organization (ILO) undertook studies to assess the impact of rising temperatures on outdoor workers' productivity. Working time loss projections as a result of global warming identified that between 1995 and 2030, in each sector, agriculture and construction, working time loss increased from 0.35 to 1.05 compared to working time loss in the service industry, which increased from 0 to 0.02 (ILO, 2019).

The decrease in productivity and the increasing percentages of working time loss in agriculture and construction, which accounts for the largest chunk of precarious workers in Egypt (Fedi et al., 2019), may be due to the phenomenon of heat stress (Rowlinson et al., 2014) which is often caused by increased wet bulb temperature (Budd, 2008; Raymond et al., 2020).

Given Egypt's high vulnerability to climate extremes, the growing poverty rates, and the growing nature of precarity in employment, it is critical to thoroughly investigate how heat waves and extreme weather events could affect construction workers to inform policy actions. This study will specifically focus on the wet bulb temperature as a climate stressor and observe how changes in wet bulb temperature could potentially affect the socioeconomic well-being of the construction worker’s household.

2.5. Literature Gap

The literature review discusses climate change and its impacts on human societies. However, while there are general statements pointing to the likelihood of climate change exacerbating poverty and inequality, particularly among the vulnerable and low-income groups (Stern, 2007), there remains limited understanding of how households involved in sectors not directly dependent on the climate (rainfall) or water availability, or low-income dwellers in areas not directly subjected to Sea Level Rise or costal issues are trapped into poverty as a result of climate change.

The literature highlights a logical understanding over the potential impact of climate change on agriculture, and coastal areas. However, there is limited to no study on how extreme weather events specifically affect Egyptians' socioeconomic well-being beyond agriculture and the phenomenon of Sea Level Rise (SLR). Several studies in Egypt assess the effect of climate change on agriculture, coastal areas, and water availability (El-Nahry & Doluschitz, 2009; Stimson Center, 2010; Wodon et al., 2014; Abutaleb et al., 2015; Ahmed, 2018; UNDP/MPED, 2021; Barakat et al., 2022), however, little to no studies exist on the effect of heat on the socio-economic well-being of construction workers beyond studies by the International Labor Organization (ILO, 2019) which quantified work time loss.

Based on the literature review, and despite a thorough search to the best of my abilities, it appears that in Egypt, the issue of heat and its socioeconomic effects, particularly on wage loss, inequality, and socioeconomic well-being among precarious workers, including construction workers, have not yet been investigated.

In summary, the forgoing suggests that there are no studies investigating how extreme weather events contribute to poverty among households not involved in agriculture or tourism in coastal areas in Egypt. While agriculture is critical for Egypt, particularly in rural areas, construction, which is not directly climate dependent, is equally important in urban areas and a major provider of livelihood for the urban working poor. Therefore, this research interest seeks to investigate the effect of heat waves captured as wet bulb temperatures on the socioeconomic well-being of construction workers in Egypt. My particular interest lies in understanding how increased wet bulb temperatures may exacerbate or not the social and economic well-being of construction workers given that in Egypt, the economy is increasingly moving from agriculture to construction industry which is fast growing in terms of jobs creation and contribution to economic growth.

Chapter Three: Contextual Framework

“The reality observed must be embedded in its context” Henri Lefebvre, (2012).

It remains critical to provide a contextual picture of the different elements discussed as part of this study. Providing a contextual framework would help in answering questions such as why focus on poverty, why focus on precarious work and construction workers, and why does it matter in the face of climate change. This section is divided into three main parts. First, I provide the socioeconomic context in Egypt including the growing issue of poverty and the seesawed movement of the GDP. Secondly, I stressed on the climate outlook in Egypt particularly the maximum and wet bulb temperature trends. Finaly, I provide a contextual picture of the construction industry in Egypt.

3.1. On the Social and Economic Crisis in Egypt

Egypt has recorded in the past decade and a half an avalanche of endogenous and exogenous shocks that affected economic growth and the socioeconomic well-being among rural and urban dwellers (Tsuchiya, 2013; Abu Hatab, 2019; Associated Press in Cairo, 2016; International Crisis Group, 2023). The 2008 global financial crisis affected “tourism revenues, remittances, exports, and investment” and negatively impacted economic growth and job creation (Tsuchiya, 2013). The 2011 revolution in the wake of the Arab Spring, which resulted in the ousting of then-President Hosni Mubarak, and the 2013 Military takeover, which toppled then-President Mohammed Mossi, further affected economic growth in the country (Abu Hatab, 2019). In 2016, Egypt recorded a currency depreciation, and in 2019, the COVID-19 outbreak further affected growth. More recently, the currency depreciation induced by a global economic crisis and the war in Ukraine exacerbated growth, likely to worsen poverty and inequality (Associated Press in Cairo, 2016; International Crisis Group, 2023).

On average, every three (3) years since 2008, Egypt has recorded a crisis affecting political stability, economic growth, and social expenditure. Figure 1 indicates that each time a crisis strikes internally or externally, Egypt's GDP suffers in the specific year or the next; furthermore, 15 years after the financial crisis, Egypt's GDP has never recovered its levels before 2008, when the economy grew at 7.2% annually. Amidst such a context, the high demographic growth is limiting the effectiveness of State-led social policies (UNDP/MPED, 2021), and further pressure on the already scarce and dwindling water resources in the country is set to affect agriculture, food security, and inflation, thus worsening already high poverty levels (Barakat et al., 2022).

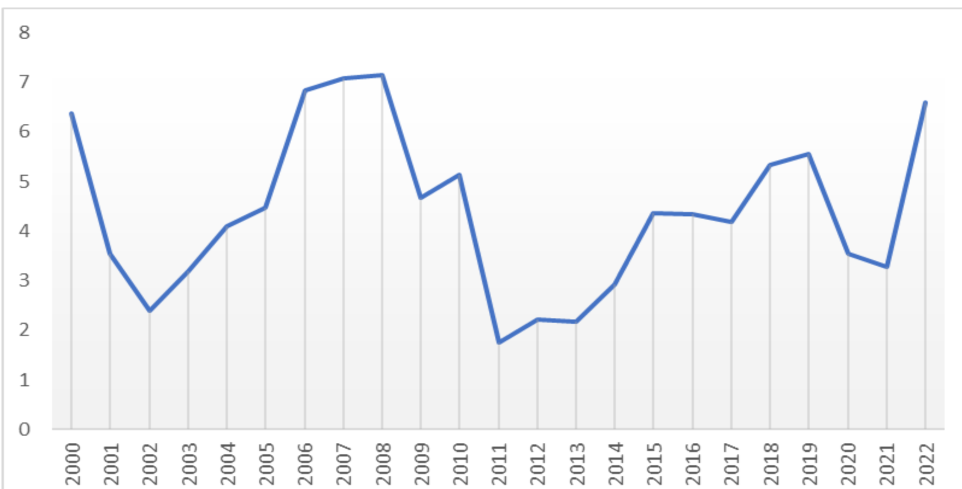

Figure 1: *Egypt GDP Growth (Annual %) (Source: Constructed by the author using 2022 World Bank National Accounts Data and OECD National Accounts Data Files on Egypt).*

The latest data suggest that poverty rates in Egypt remain at 29.7 % (World Bank, 2023). Since the 2008 financial crisis, the poverty rate has increased year on year, reaching its peak of 32.5% in 2017/2018 before decreasing to 29.7% in 2019 (UNDP/MPED, 2021), as indicated in Figure

2. While poverty rates decreased from 32.5% in 2017 to 29.7% in 2019, the number of poor increased from 31.3 million (World Bank, 2021) to 31.9 million (World Bank, 2023).

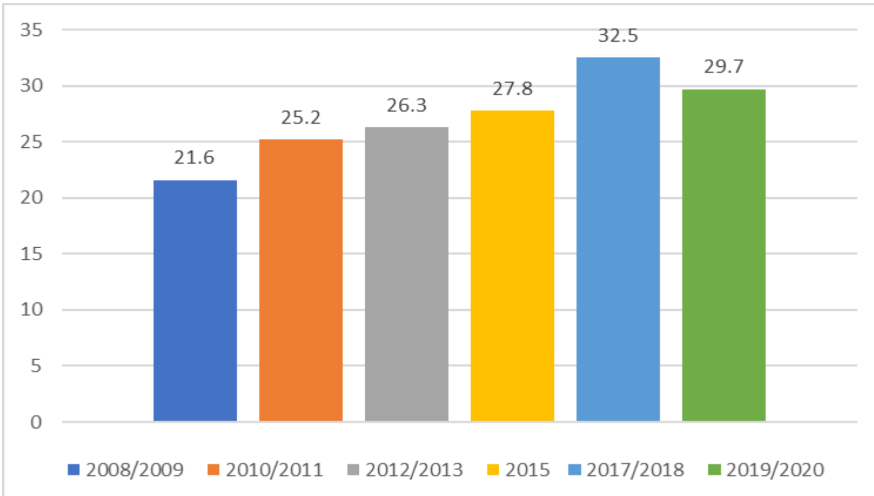

Figure 2: *Egypt poverty rate (Annual %) (Constructed by the author using poverty data from the 2021 Egypt Human Development Report (UNDP/MPED, 2021)*

The recent economic context in Egypt, including the currency devaluation and the high inflation rates have worsened the plight of the poor in the country (Magdy, 2024). Speculations suggests the number of poor to considerably increase as a result of such economic shocks (Michaelson, 2023). Amidst such a background of internal and external crisis and the growing rates of poverty, climate change and its associated extreme weather events is emerging as a stressor set to worsen poverty and inequality in Egypt, particularly among construction workers (Wodon et al., 2014; ILO, 2019).

3.2. Egypt: A climate Hotspot

Heat waves are naturally occurring climate phenomena; however, their frequency, magnitude, and duration have increased due to climate change (Morsy & El Afandi, 2021). Today, Egypt is among countries considered to be climate hotspots (Morsy & El Afandi, 2021; Duenwald et al., 2022). Over the years, Egypt has recorded changes in maximum temperatures manifested as indicated in Figure 3.

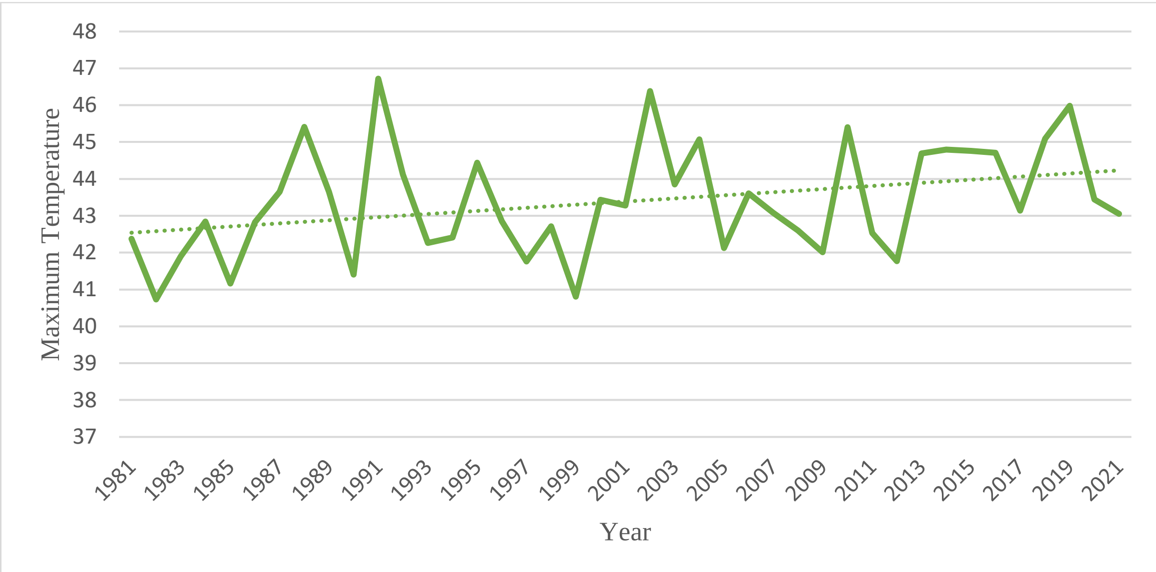

Figure 3: *Maximum Temperature in Egypt in June, July, and August from 1981-2021 (Constructed by the author using Meteorological Data from NASA Power Project)*

The average trendline in Figure 3 indicates that the maximum temperature in Egypt (including all the governorates) is increasing from 42.38 in 1981 to 43.05 in 2021, with an unprecedented extreme heat at 46.38 degrees in 2002 and episodes of extreme heat. Increasing temperatures and heat waves are also climate stressors, and their impact on precarious workers has been the center of several studies. Wet Bulb Temperatures (WBT) are critical in assessing the effect of heat on the productivity and physical well-being of outdoor workers (Raymond et al., 2020). Figure 4 highlights the historical trend of WBT in Egypt.

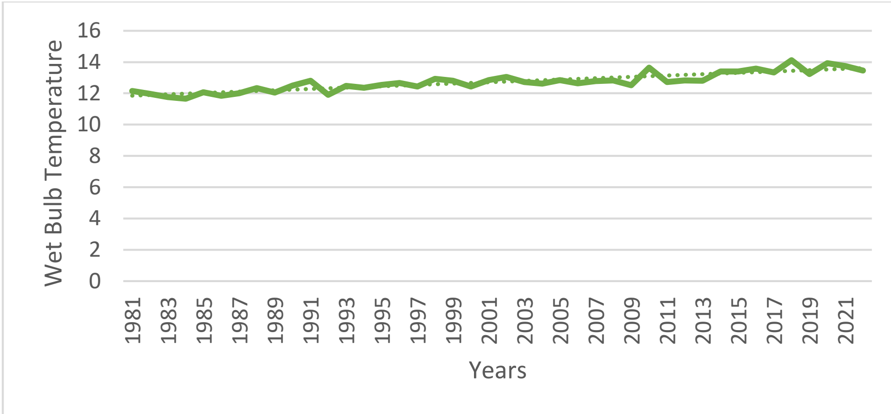

Figure 4: *Annual Average Wet Bulb Temperature Trend in Egypt from 1981-2021 (Constructed by the author using Meteorological Data from NASA Power Project).*

The average trendline in Figure 4 shows an increasing annual mean WBT across Egypt. The figure highlights the wet bulb temperature moved from 12.16 in 1981 to 13.45 in 2021. Based on figures 3 and 4, Egypt is warming up, and climate change is an emerging stressor likely to exacerbate citizens' well-being (Stern, 2007; Morsy & El Afandi, 2021; Duenwald et al., 2022). It is against this backdrop that this study seeks to analyze the effects of Wet Bulb Temperature (WBT), as a climate change-induced phenomenon, on the socioeconomic wellbeing of construction workers.

3.3. The Construction Industry in Egypt

The Construction industry remains a significant part of the Egyptian economy. From 1998 to date, the sector has recorded tremendous growth and is meant to drive economic development in Egypt **(**Assaad et al., 2019; Kshaf et al., 2022). Given the major infrastructural projects launched by the government, the construction industry is projected to grow from 6.8% in 2023 to 7.4% in 2027 (Ahram Online, 2023). Between 2015 and 2019, the construction industry has recorded one of the fastest creation of jobs particularly among bricklayers and stonemasons, (Hendy &

Hassan, 2023). A major contributor to this remains the real estate boom which contributed to increasing construction jobs from 7% in 1998 to 13% in 2018 (Assaad et al., 2019).

While the expansion of the construction industry remains critical for the Egyptian economic growth, 90% of employment remain precarious, and most of them are irregular, and informal, with poor working conditions which are strongly associated with poverty (Fedi et al., 2019; Assaad et al., 2019). While 40% of construction workers remain unregistered (Ahram Online, 2021), 90% of the workers employed with construction compagnies (both in public and private companies) are on temporary contracts (El Ehwany, 2009). Although some workers may have contracts, such documentation remains irregular, temporary, and out of the formal establishment (El Ehwany, 2009; Assaad et al., 2019).

In recent years, the construction industry has recorded transformations in its organizations. Contractors engaged to implement construction projects employ sub-contractors who are mostly responsible for 90% of the construction project (Kshaf et al., 2022). Thus, sub-contractors are the ones responsible to secure skilled workers on site. While there are laws prohibiting the employment of unregistered workers, sub-contractors tend to disregard this fact (El Ehwany, 2009). Therefore, the construction worker on the site is at the lowest hierarchical point having to face the site engineer, the sub-contractor, and the main contractor before voicing their issues.

The International Labor Organization (ILO) estimates that climate change would contribute to working time loss in construction from 0.35 to 1.05 as demonstrated in figure 5. Overall, the working time loss, which is based on productivity calculations, in Egypt is set to result in the loss of 134 thousand jobs by 2030 (ILO, 2019).

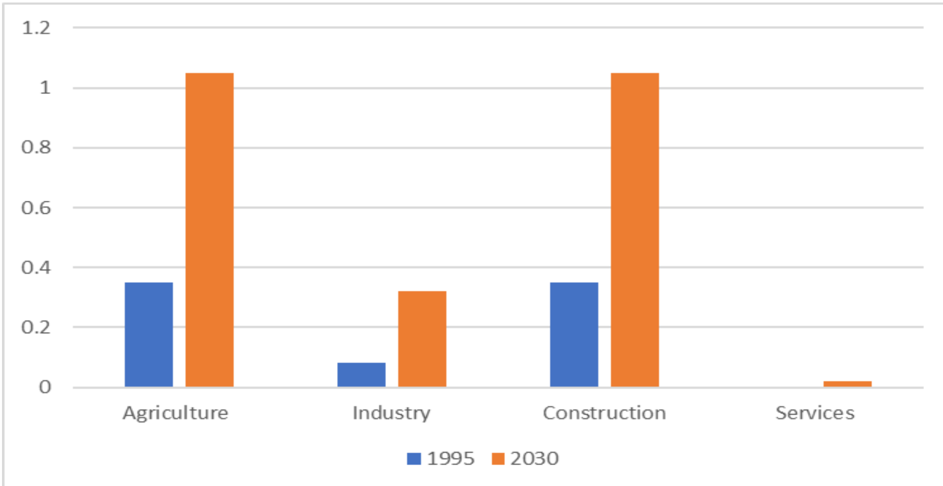

Figure 5: *Working Time loss projection from 1995 to 2030 per sector (Source: Constructed by the Author based on data from the International Labor Organization (ILO, 2019)*

Climate change is predicted to affect the socioeconomic wellbeing of outdoor workers most of whom are precarious workers including those in the construction industry, and trap them in the vicious circle of poverty (Venugopal et al., 2016; ILO, 2019; Orlov et al., 2019; Narocki, 2021). Therefore, this study will dive into understanding in what ways climate change, through the phenomenon of Wet Bulb Temperature (WBT) would contribute to locking the construction worker in poverty.

Chapter Four: Study Design

"In scientific research, the method of analysis must fit the matter being studied. One must avoid using political economy tools in physics and chemistry" Henri Lefebvre, (2012).

Different research approaches and techniques contributed to this study. Therefore, this chapter provides details on the research method adopted. The Chapter is divided in the following six parts: *i)* highlights the conceptual framework which will guide the study and establishes the relationship among key terms; *ii)* stressed the methodology adopted in this study including the different paradigms from which I conduced my analysis; *iii)* provides details over the quantitative data sources including the weather data, the datasets used in the study and the study hypothesis; *iv)* gives details on how the dataset was organized and the econometric model used; *v)* provides highlights the qualitative research method, and underlines the data sources, interviewees characteristics, and how the data was analyzed*; vi)* elaborates on the study limitations.

4.1. Establishing the Conceptual Framework

The effects of climate change on human societies are considered as loss and damage (UNFCCC, 2012; Chiba et al., 2017; Eckstein et al., 2021). Therefore, any effect of climate change on humans recorded during this study is considered as loss and damage.

This study identifies two main concepts as key variables: Climate change and poverty. Climate change is manifest to humans through extreme weather events, some of which include acute heat waves, drought, precipitation, etc. (NASEM, 2016; Otto, 2019). Heat waves induce Wet Bulb

Temperature (WBT), which is a suitable metric in studying the effect of heat on human activities (Orlov et al., 2019; Raymond et al., 2020). This study operationalizes climate change as WBT.

Low-income households are more vulnerable to climate change, and the losses and damages contribute to poverty (World Bank, 2014; Ullah et al., 2017; Waha et al., 2017; Eckstein et al., 2021). Among the working population, low-income groups are known as the working poor, most of whom are precarious workers in the informal economy (OECD/ILO, 2019; Gunn et al., 2021). Among precarious workers are cleaners, garbage collectors, construction workers, etc. (ILO, 2019; Assaad et al., 2019; Hendy & Hassan, 2023). The construction industry by design accounts for a large chunk of precarious workers, about 90% (Fedi et al., 2019). This study focuses on construction workers as working poor.

The incidence and exacerbation of poverty and inequality are recurring statements when discussing the impact of climate change (Stern, 2007; Waha et al., 2017; IPCC, 2022). The operationalization of socioeconomic well-being among construction workers includes wage loss, health expenditure, children's educational expenditure, cultural and recreational expenditures, and housing expenditure (Venugopal et al., 2016; Kjellstrom et al., 2016; Nunfam et al., 2019). This study, however, focuses on wage loss, food expenditure, and health expenditure. The conceptual framework in Figure 6 indicates the conceptualization of the key variables.

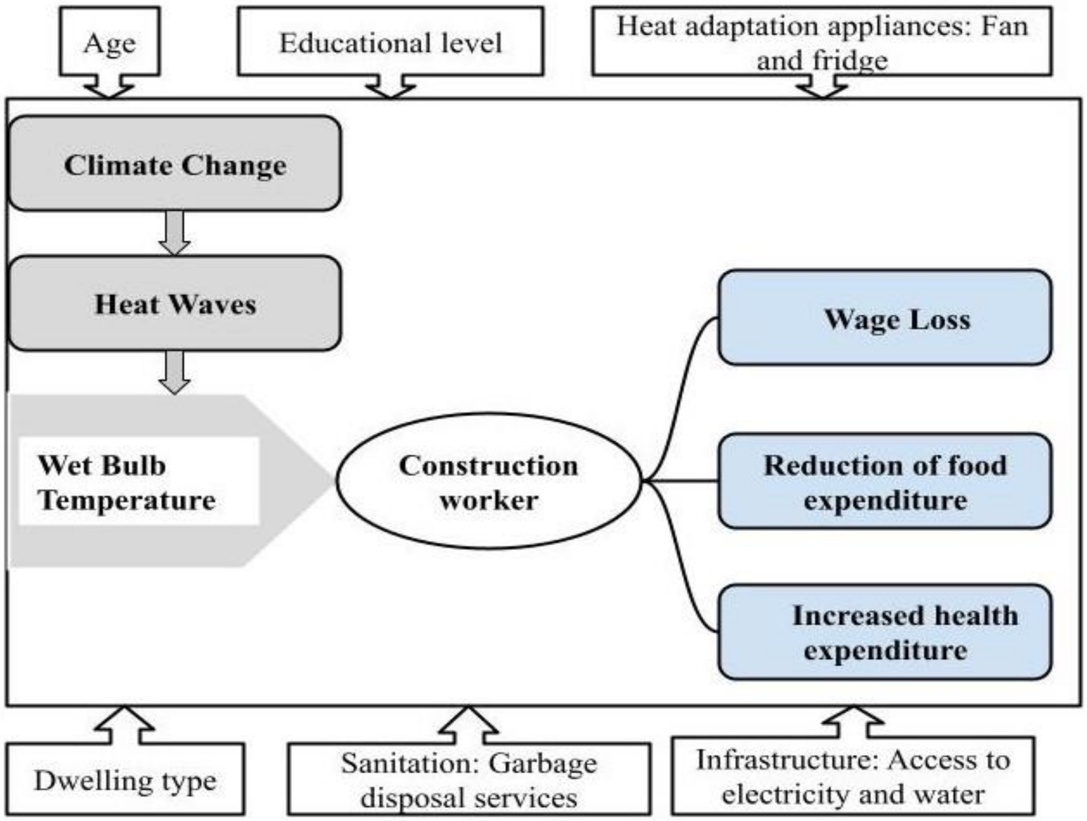

Figure 6: Conceptual Framework: Effect of Wet Bulb Temperatures on the Socioeconomic Well-being of Construction Workers (Source: Author inspired by Islam & Winkel, 2019)

The conceptual framework in figure 6 captures the key findings in the literature related to the impact of increased WBT on construction workers. Based on the literature review, climate change generates extreme weather events including heat waves which also lead to the WBT. When WBT affect construction workers, it is likely to result in wage loss, decreased food expenditure, and increased health expenditure. Such impacts are to result in increasing worker’s household vulnerability to poverty. However, there are contextual elements which could affect the relationship between increased WBT and the socioeconomic well-being of the construction worker. Factors such as the region in which the construction worker’s household is located, the worker’s age and educational level, the type of housing in which they reside, their accessibility to infrastructure such as water, electricity, and garbage disposal services, and the ownership of appliances such as a fridge and a fan.

Inflation and currency devaluation are critical factors in analyzing financial well-being. However, in this study, inflation is not included in the model because it has little to no effect on the quantitative regressions and causes collinearity with other variables when included in the model. Devaluation is also not included in this study due to its irregularity in Egypt and the challenges in capturing it in a model. To mitigate the effects of these economic factors, data in this study stops at 2015 before the currency devaluation and spiking inflations in 2016. In fact, from 2008 to 2015, inflation in Egypt decreased from 18.3% to 10.4% (World Bank, 2024). This reduction of inflation in my year of interest further decreases the importance of adding inflation as a variable. Considering data from 2008 to 2015 insulates the analysis and dataset from exogeneous economic shocks. Given that income is the most important variable in this study, I developed two econometric models for wages and income: One econometric model with current income values and another one with the values adjusted to the Consumer Price Index (CPI) to capture the real value of income and wages.

4.2. Research Methodology

This study adopts a mixed methodology as done by Das (2015), Venugopal et al. (2016), and Orlov et al. (2019), who studied the effects of heat waves on construction workers in India and Europe. Quantitative research leverages hard data and establishes a relationship between variables (Neuman, 2013). The qualitative side captures people’s realities and interpretations of the quantitative observations (Lune & Berg, 2017). The first part of the study focuses on the quantitative approach. Findings based on economic models helped inform the qualitative approach.

The studies in India and Europe reveal two main techniques in conducting a quantitative analysis of WBT and their impacts on construction workers. The first technique starts by identifying years with high WBT, quantifying productivity loss through workers' annual output in the construction industry, and quantifying the difference between outputs in years with low temperatures and years with high temperatures through macroeconomic cross-sectional datasets, (Orlov et al., 2019). The second technique uses surveys conducted during heat waves where researchers observed workers and correlated the recorded productivity loss and socioeconomic impacts (Das, 2015; Venugopal et al., 2016).

In this study, I leverage the method by Orlov et al. (2019) and perform minor changes. Instead of using trade and economic transaction datasets that capture macro data on the construction industry, I use the Egyptian Household Income and Consumption Survey (HIECS). The HIECS is able to directly target the annual variables of the construction worker's household. Targeting the household is proven to be the best approach to assessing vulnerability to poverty among developing countries. Furthermore, social welfare programs often target households. Just as done by Orlov et al. (2019) this study is conducted based on datasets of years having recorded peak temperatures and years with lower temperatures as reference. Choosing a year with low temperature and comparing variables with years having recorded high temperatures was also used by Baquie and Fuje (2020) in Malawi when assessing the impact of extreme weather events on poverty vulnerability. The study also leverages Das (2015) and Venugopal et al. (2016) methodology and conducts interviews to mine data.

This study seeks to observe and excavate empirical relationships between variables. According to Neuman (2013), studies “discovering causal laws” are Positivist. Thus, on the first level, this study adopts a positivist theory and bases observations on a deterministic approach. This means that the humans observed are impacted by natural laws, which they can do nothing against. A second layer of the study requires engagement with the humans to discuss their understanding and perception of variables, their realities, and context. Thus, rely on the recommendation from Neuman (2013) and adopt an Interpretative approach. The research is based on a Reconstructed logic. Thus, instead of starting open to new processes and changes defined by the participants (Lune & Berg, 2017), the reconstructed logic consists of a tested study approach and a straightforward step-by-step approach (Neuman, 2013).

4.3. Quantitative Study Design

4.3.1. Weather Data

The first part of the study is quantitative, and the analysis cuts across Egypt. The second part, which is qualitative, would zoom into Cairo as a case study of an urban area. A critical part of the study remains the selection of years in which the variables would be observed. Figure 3 in the literature review shows the maximum temperature trends in Egypt from 1981 to 2021.

To carry out the study, I leverage the strategy used by Orlov et al. (2019) and select years with high temperatures. In this study, I select 2008, 2010, and 2015 for the analysis. This choice is because 2008 recorded low temperatures, which is considered a reference year, while in 2010 and 2015, there were record-breaking heat waves. In 2008, the average annual maximum temperature was 42.6 degrees. In 2010 and 2015, the average annual maximum temperatures were 45.4 degrees and 44.76 degrees, respectively. Given that this study is interested in the effect of climate change on workers, instead of considering only heat, I will also consider humidity. The variable merging both heat and humidity among humans is the WBT. The WBT is the major determinant of humans' ability to withstand heat. Increased WBT affects human productivity (Raymond et al., 2020). Furthermore, the study leverages the choice by Orlov et al. (2019) in selecting WBT as the main climate variable. Based on the years with high temperatures, I selected the years with high WBT. Figure 4 in the literature shows a trend of WBT across Egypt from 1981 to 2021. In 2008, the wet bulb temperature was 12.83. In 2010 and 2015, the WBT were 13.65 and 13.04, respectively.

4.3.2. Household Income, Expenditure, and Consumption Survey (HIECS) Dataset

The dataset used for this study is the Egyptian Household Income, Expenditure, and Consumption Survey (HIECS) implemented by the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS). I gained access to the dataset following a formal request to the Economic Research Forum (ERF). The HIECS assesses the living standards of Egyptians and is the main poverty measurement tool in Egypt. The survey is conducted every two years since 2008. This allows a close tracking of changes among the population. The HIECS provides annual cross-sectional data. The selection of the datasets is based on the weather data selection. Thus, 2008, which recorded low WBT, is considered a reference year compared to 2010 and 2015, which recorded high WBT. The sample size of the dataset is nationally representative, with observations distributed across all the governorates of Egypt. Households selected as part of the survey are observed for two weeks; however, the observation periods may vary as the data collection is conducted in phases of quarters throughout the year. In this study, the household is the main unit of analysis.

While analyzing trends often requires panel data, this study leverages the HIECS cross-sectional datasets and flows the footprints of studies by Orlov et al. (2019) in Europe and Baquie & Fuje (2020) in Malawi. Furthermore, among developing countries, using HIECS, despite its cross-sectional nature and limitations, could offer policy insights and is the tool used in assessing poverty trends and vulnerability to poverty (Chaudhuri et al., 2011). Table 1 and Table 2 highlight summaries of the datasets used in this study.

Year	**Observation Number**		**Total Observations**	**Data collection period**
	Rural	**Urban**		
2008	12,657	10,771	23,428	April 2008 - March 2009
2010	4,132	3,587	7,719	July 2010 - June 2011
2015	6,767	5,221	11,988	January 2015 - December 2015
Total Observations			43,135	

Table 1: ***Number of Observations per dataset (Source: Constructed by the author using 2008, 2010, and 2015 HIECS on Egypt).***

While the sample is large as highlighted in Table 1, this study is particularly interested in construction workers. Table 2 shows the number of observations recorded among construction workers over the years.

Year	Observation Number		Total Observations	Data collection period
	Rural	**Urban**		
2008	843	810	1,653	April 2008 - March 2009
2010	380	279	659	July 2010 - June 2011
2015	503	361	864	January 2015 - December 2015
Total Observations			3,176	

***Table 2:** Number of Observations per dataset for construction workers only (Source: Constructed by the author using 2008, 2010, 2015 HIECS on Egypt).*

4.3.3. Variables of Interest

Ultimately, I aim to understand how climate change contributes to poverty among precarious workers. Critical variables of this study are captured in Table 3. Based on studies related to both poverty measurement and climate change, this study considers a set of five (5) dependent variables against which wet bulb temperatures will be regressed. To capture the household characteristics, this study controls eleven (11) variables likely to affect the effect of climate change on the incidence of poverty within a household.

Variables	Observations	Mean	Std. Dev.	Min	Max
Dependent Variables					
Net Wage	2,535	15495.57	11744.16	600	213000
Self-Employment Income	1,638	14433.92	19236.63	150	250000

Total Purchased Food	3,176	8486.8	4352.661	123.5	55674
Health Expenditure	3,146	1355.766	3077.857	6	94585
Pharmacy/Medical Expenditure	3,132	715.0207	1287.051	7	25400
Main Independent Variables					
Wet Bulb Temperature	3,176	15.0191	2.507044	0	19.09
Controlled Variables					
Year	3,176	2010.319	2.963731	2008	2015
Region	3,176	16.45749	8.957929	1	35
Age Household Head	3,176	40.65963	10.13333	18	75
Sex Household Head	3,176	1.000945	0.030724	1	2
House head Educational Level	3,176	2.058249	1.170534	1	6
Dwelling Type	3,176	275.1385	89.20707	110	420
Access to Water	3,176	1.20403	0.603869	1	5
Access to Electricity	3,176	0.991814	0.090122	0	1
Garbage Disposal	3,176	353.3407	241.1563	110	740
Fridge Ownership	3,176	0.889484	0.313582	0	1
Fan Ownership	3,176	0.495907	0.500062	0	1

***Table 3:* Study Variables Summary (Source: Constructed by the author using 2008, 2010, and 2015 HIECS on Egypt)**

4.3.4. Net Wage and Self-Employment Income

Studies analyzing the effect of climate change on poverty first considered income. Several researchers highlighted that increasing temperatures are set to decrease income, particularly among outdoor low-income precarious workers such as construction workers (Stern, 2007;

Venugopal et al., 2016; ILO, 2019; Orlov et al., 2019; Narocki, 2021). Furthermore, measuring poverty within a household relies on either the household's income or consumption (Brown et al., 2022). In this study, the dataset captures both Net Wage, that is, the wage for construction workers who are employed, and Self-Employment Income, which represents the revenue of construction workers who are self-employed on their own account. The regression analysis will observe the effect of the WBT on net wage and self-employment Income. According to the literature, as WBT increases, income decreases among construction workers (Venugopal et al., 2016; Orlov et al., 2019; Narocki, 2021).

Hypothesis 1: Increased wet bulb temperature decreases the net wage of construction workers' households in Egypt.

Hypothesis 2: Increased wet bulb temperature decreases the self-employment income of construction workers households in Egypt.

4.3.5. Total Purchased Food

Another method in assessing a household's vulnerability to poverty is by assessing how exogenous shocks affect their consumption, given that income often fluctuates, particularly in developing countries (World Bank, 2014; Baquie & Fuje, 2020; Brown et al., 2022). Low-income households often spend most of their income (50 to 70%) on food (IMF, 1985). As temperatures increase and income potentially reduces, construction workers spend most of their income on food and water (Das, 2015). However, further studies revealed that increased temperatures contribute to food inflation and reduce the purchasing power of low-income urban dwellers (Stern, 2007; UNDP/MPED, 2021; Barakat et al., 2022) and could contribute to malnutrition as they reduce their food intake (Chiba et al., 2017). Income loss can also reduce purchasing power. This makes food more expensive for the poor, who end up switching to low-quality food or reducing their daily overall consumption of food (Amaglobeli et al., 2023). In this study, I consider that increased WBT decreases food consumption among construction workers' households. By considering income and consumption, this study conducts a comprehensive analysis of the household's vulnerability to increased temperatures.

Hypothesis 3: Increased wet bulb temperature decreases total food consumption among construction workers' households.

4.3.6. Health Expenditure and Pharmacy/Medical Expenditure

Multiple studies analyzed how heat waves and wet bulb temperatures increase risks of occupational health issues, particularly heat stress and heat stroke among construction workers (Kjellstrom et al., 2016; Chiba et al., 2017; El-Shafei et al., 2018; ILO, 2019). Given such impacts, increased wet bulb temperature is set to increase health expenditure among precarious workers (Stern, 2007; Anderson, 2010; Nunfam et al., 2019). The dataset first captures household health expenditure, which comprises expenses incurred by the household when they visit a hospital. However, Egypt experiences health inequality where about 30.8%, most of whom are poor, have incomplete access to health services (Ahmed, 2020). Furthermore, most low-income households, of which those of construction workers are in the informal sector, do not benefit from health insurance (UNDP/MPED, 2021). Thus, out-of-pocket health expenditures in Egypt remain high (Ahmed, 2020). Pharmacy/Medical Expenditure as a variable captures most out-of-pocket health expenditures, including expenses to purchase ice bags, serums, vitamins, minerals, etc., which are critical health expenditures when the temperature is high. This study, therefore, captures both variables of expenditure in hospitals for treatment and expenditure for Pharmaceutical/Medical products expenditures.

Hypothesis 4: Increased wet bulb temperature increases Pharmaceutical/Medical Expenses among construction workers' households.

Hypothesis 5: Increased wet bulb temperature increases health expenditure among construction workers' households.

4.3.7. Controlled Variables:

Several other factors could affect the socioeconomic well-being of low-income households. Therefore, it is critical to include a set of variables in the econometric model to improve the robustness of the findings.

- **Year:** Given this study uses cross-sectional data and that it is also relaying a reference year, which is 2008, I control for the year to account for potential variations in each year in the study. This approach is also used by Baquie and Fuje (2020) in Malawi when assessing the effect of flooding on household consumption.
- **Region:** Location is critical in this study, given that the wet bulb temperature could vary from one place to the other. Therefore, the study also controls for the regions where the construction workers' households are located. This approach is also used by Baquie and Fuje (2020) in Malawi when assessing the effect of flooding on household consumption.
- **Biography of the construction worker: Age of Household Head, Sex of Household Head, House head educational level:** Individual characteristics are also factors likely to affect income. Most studies and recommendations on measuring a household's

vulnerability to poverty further recommend or have considered these factors (IMF, 1985; Chaudhuri et al., 2011; Baquie & Fuje, 2020).

- **Enabling Environment: Dwelling Type, Access to Water, Access to Electricity, Garbage Disposal, Fridge Ownership, and Fan Ownership:** Access to social and administrative public services such as access to electricity, water, and garbage disposal are critical factors to consider in studies aimed at measuring households' vulnerability to poverty and their ability to withstand climatic events (IMF, 1985; Su et al., 2022; Alkire et al., 2020). While over recent years, the Egyptian government has made progress in improving access to infrastructures and public services, this study considers datasets and temperatures from 2008 to 2015, which was a period when access to infrastructure and public services was critical. Fridge and fan ownership are considered critical household equipment for adaptation among construction workers. They allow workers to adapt better, and be more productive in their work (Das, 2015; Narocki, 2021).

4.4. Econometric Model

4.4.1. Organizing the dataset

- **Year Selection and temperature data:** As discussed in the study methodology and terms operationalization, the first analysis consisted of identifying years with low temperatures and years with high temperatures. I first conducted an analysis of average temperatures in June, July, and August from 1981 to 2021 to identify years with the highest levels of heat in summer. Secondly, I compared average summer temperatures to total average annual temperatures. In 100% of cases, years with the hottest summer recorded high annual average temperatures. There is a correlation between high temperatures and wet bulb temperatures. As temperatures increase, so does the wet bulb temperature. In 100% of cases, years with the hottest summers and annual temperatures had the highest wet bulb temperatures. Based on this analysis, I selected 2008 as the reference year, which recorded relatively low temperatures, and 2010 and 2015 as years that recorded high temperatures. I proceed to download the wet bulb temperature data of each of the twenty-seven (27) governorates in Egypt by manually inputting the longitude and latitude coordinates of each governorate in the NASA Power weather data website.

- **Appending datasets:** I proceeded in appending the datasets of 2008, 2010, and 2015 to have a unified dataset for the analysis.
- **Generating new variables:** I generated Wet Bulb Temperature (WBT) as a new variable and manually imputed the wet bulb temperature of each of the 27 governorates for each year 2008, 2010, and 2015.
- **The Consumer Price Index:** Although adding the variable of inflation in the model generates collinearity issues, I generated the variable of the Consumer Price Index (CPI). The CPI provides an estimated price of a basket of goods and services representing the average household spending and is an indicator of inflation. Although the econometric model I developed is based on an approach to insulate variables from inflations and currency devaluation, the CPI helps me adjust wages and income based on the inflation levels in a specific period. Based on the CPI variables I generated new variables of wage and self-employment income adjusted to inflation. This approach helps capture the effect of inflation and avoid collinearity. I gained access to Egypt's CPI from the World Bank Data Portal.

- **Renaming:** I renamed all the relevant variables in this study for easy reading and analysis throughout the research.

4.4.2. Econometric model

In this study, I conducted a multiple regression model for each of the dependent variables in the five (5) hypotheses. I operated some settings to control for all the variables before the regression.

xi: Interaction Expansion: This Stata syntax allows to expend variables containing categorical variables into dummies in a model. **xi:** automatically sets the regression so as to omit one of the dummies against which the analysis is done. In this study, xi: automatically drops the ***Year 2008.***

i.: Factor variable: This Stata syntax automatically creates dummies on categorical variables. The factor variable syntax is used to control for ***year*** and ***region*** variables.

The Regression analysis is meant to capture how the dependent variable **y** is affected by changes in independent variables **x** all other variables held constant, thus ***Ceteris Paribus***.

The Econometric Model is as follows:

H1: Increased wet bulb temperature decreases net wage among construction workers' households[1]

xi:**Y**(Net_wage)=**βx0**(Coefficient)+**βx1**(WetBulbTemperature)+**βx2**(Age_Household_Head)+**βx 3**(Sex_Household_Head)+**βx4**(Househead_Educational_Level)+**βx5**(Dwelling_Type)+**βx6**(Acce

[1]*I run the econometric model on Hypothesis 1 and 2 twice. One version with current values of Income, and another model with the CPI adjusted values of Income.* The outcome of the CPI-adjusted wage and income is accessible in the appendix.

ss_To_Water)+**βx7**(Access_to_electricity)+**βx8**(Garbage_Disposal)+**βx9**(Fridge_Ownership)+**βx10**(Fan_Ownership)+ **i.βx11**(i.year)+**i.βx12**(i.region)+**ϵ**(residual/factors not captured in model)

H2: Increased wet bulb temperature decreases the self-employment income of construction workers' households[1]

xi:**Y**(Self_employment_Income)=**βx0**(Coefficient)+**βx1**(WetBulbTemperature)+**βx2**(Age_Household_Head)+**βx3**(Sex_Household_Head)+**βx4**(Househead_Educational_Level)+**βx5**(Dwelling_Type)+**βx6**(Access_To_Water)+**βx7**(Access_to_electricity)+**βx8**(Garbage_Disposal)+**βx9**(Fridge_Ownership)+**βx10**(Fan_Ownership)+**i.βx11**(i.year)+**i.βx12**(i.region)+**ϵ**(residual/factors not captured in the model)

H3: Increased wet bulb temperature decreases total food expenditure among construction workers' households

xi:**Y**(Total_Purchased_Food)=**βx0**(Coefficient)+**βx1**(WetBulbTemperature)+**βx2**(Age_Household_Head)+**βx3**(Sex_Household_Head)+**βx4**(Househead_Educational_Level)+**βx5**(Dwelling_Type)+**βx6**(Access_To_Water)+**βx7**(Access_to_electricity)+**βx8**(Garbage_Disposal)+**βx9**(Fridge_Ownership)+**βx10**(Fan_Ownership)+ **i.βx11**(i.year)+ **i.βx12**(i.region)+**ϵ**(residual/factors not captured in the model)

H4: Increased wet bulb temperature increases pharmacy and medical expenditure among construction workers' households.

xi:**Y**(Pharmacy/Medical_Expenditure)=**βx0**(Coefficient)+**βx1**(WetBulbTemperature)+**βx2**(Age_Household_Head)+**βx3**(Sex_Household_Head)+**βx4**(Househead_Educational_Level)+**βx5**(Dwel ling_Type)+**βx6**(Access_To_Water)+**βx7**(Access_to_electricity)+**βx8**(Garbage_Disposal)+**βx9**(Fridge_Ownership)+**βx10**(Fan_Ownership)+ **i.βx11**(i.year)+ **i.βx12**(i.region)+ϵ(residual)

H5: Increased wet bulb temperature increases health expenditure among construction workers' households.

xi:**Y**(Health_Expenditure)=**βx0**(Coefficient)+**βx1**(WetBulbTemperature)+**βx2**(Age_Household_Head)+**βx3**(Sex_Household_Head)+**βx4**(Househead_Educational_Level)+**βx5**(Dwelling_Type)+**βx6**(Access_To_Water)+**βx7**(Access_to_electricity)+**βx8**(Garbage_Disposal)+**βx9**(Fridge_Ownership)+**βx10**(Fan_Ownership)+ **i.βx11**(i.year)+ **i.βx12**(i.region)+ϵ(residual/factors not captured in model)

4.5. Qualitative study design

"Nothing can replace your contact with the matter, analyzing it, and capturing it's reality"

Henri Lefebvre (2012).

Despite the robustness of the quantitative design of this study, the recommendation by Lefebvre when discussing the analytical method in Marxism triggered my desire to come in contact with construction workers. This informed the qualitative part of this study.

4.5.1. Study Site

While the quantitative model covers Egypt as a whole, this qualitative side would constitute a case study focusing on Cairo, particularly New Cairo, an urban extension of Cairo that has recorded a spiking rate of construction projects, including the New Administrative Capital project. This qualitative approach helps move beyond the numbers and capture contextual factors that better explain the empirical results from the econometric model.

Cairo as a whole, including New Cairo, has recorded extreme temperatures as well Egypt. Figures 7 and 8 show a trend in extreme temperatures in Cairo from 1981 to 2021.

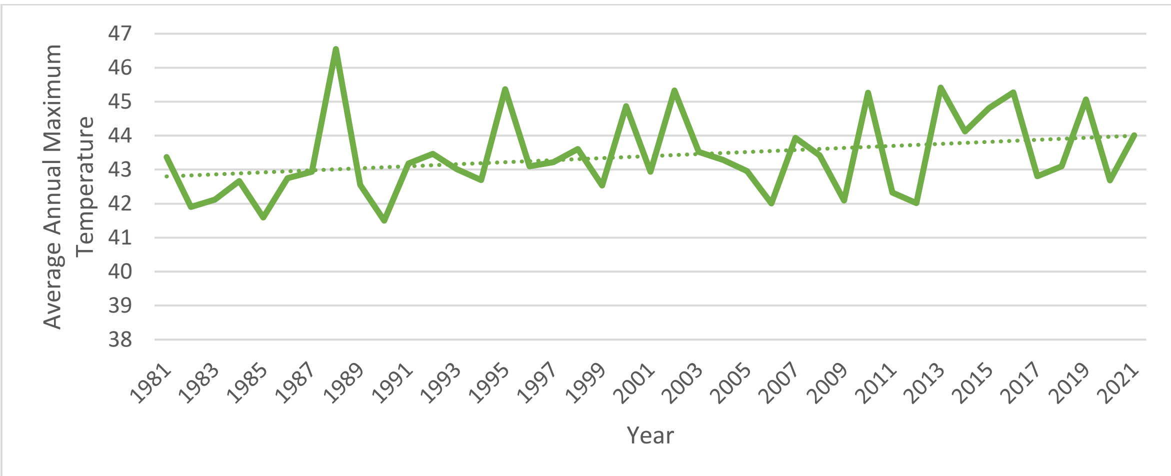

Figure 7: *Average Annual Maximum Temperature Trend in Cairo from 1981-2021 (Constructed by the author using Meteorological Data from NASA Power Project).*

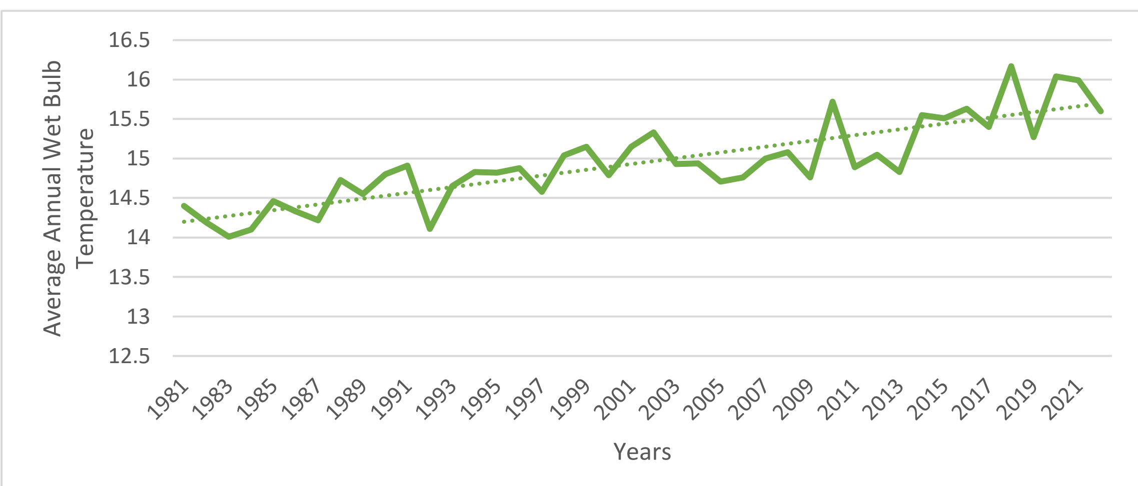

Figure 8: *Average Annual Wet Bulb Temperature trend in Cairo from 1981-2021 (Constructed by the author using Meteorological Data from NASA Power Project).*

While figure 7 shows a steady but slow increase in temperatures since 1981, figure 8 shows a sharp spike of the WBT in Cairo. This means that outdoor workers in Cairo are more and more struggling under the heat. While cities such as Aswan, Luxor, and Assiut are hotter than Cairo in the summer, the fact that New Cairo is being built literally in the desert and attracts massive numbers of construction workers from rural areas makes this site selection best for the study.

4.5.2. Data Sources

The qualitative data is collected through semi-structured interviews on one-on-one, dyads, and triads with construction workers selected based on purposive sampling. Purposive sampling consists of selecting participants that meet certain eligibility criteria (Neuman, 2013). This study considers construction workers with at least 5 years of experience who are currently working on a construction project in New Cairo, and who have worked in recent years on construction sites during the summer. I collected the data on active construction sites between 12 pm and 1 pm when the workers were on break. To engage the construction workers, I booked an appointment with the site engineers to have their approval. Given my limited linguistic abilities in Arabic, three (3) graduate students who have all completed the Institutional Review Board (IRB) training and who have received their certificates supported in interpreting the interviews. We first visited the construction sites to meet site engineers to book appointments, and later on proceeded with the interviews. In total, the interview recorded 10 participants interviewed on 4 construction sites. However, I later discarded the data from one worker who highlighted he was working part-time. The Characteristics of the interviewees are highlighted in Table 4.

Number of Interviewees	Interviewees	Years of Experience
7	Construction Worker (Specialized in breaking walls, carrying bricks, and laying bricks)	Between 5 - 15 years (4)
	Construction Worker (specialized in carpentry and ironwork)	Between 5 - 15 years (2)
	Construction Worker (setting the ties)	Between 20 - 25 years (1)
2	Site Engineer	Between 3 - 5 years (1) with 6 active workers. Between 20 - 25 years (1) with 30 active workers.

***Table 4:* Interviewees characteristics (Source: Author)**

4.5.3. Data Collection and Analysis

The data collection was organized into 3 phases, with a 24-hour pause between each phase. The 24-hour pause allowed me to process data from each interviewee and potentially inform the next phases. These 24-hour pauses informed the change in format from triads into dyads. Also, from phase one where I acquired preliminary data, I was able to inform the next two phases with key terms such as "freelance" to qualify self-employed construction workers, "poverty" "suffering" "help" and "government" "strong" which are keywords that triggered memories, trust, and allowed workers to open up.

Phase 1: Here I conducted one interview with a site engineer and one triad interview. After one hour I conducted a second interview. These data provided preliminary understanding. Having the first interview with the site engineer provided a general overview of how the human resource in construction is organized. This also facilitated engagements with other workers.

Phase 2: Here I conducted 2 interviews. One with a construction worker, and one with a site engineer. Again, here I first interviewed the site engineer who provided critical data on contextual issues including contracts for construction workers, heat management on the construction site, etc.

At the phase 2 level, I had already engaged seven (7) participants and already detected a level of saturation. I proceeded with the last phase to confirm whether or not new insights would emerge.

Phase 3: Here I conducted a dyad interview with two construction workers. This phase allowed me to validate the data collected during phases 1 and 2 and to confirm the data saturation on the variables I sought to capture. The stories recorded were similar after engaging 9 participants and did not generate new insights. Consequently, I had reached data saturation.

Tracking of Two Workers: During the data collection, two workers I interviewed were on a construction site which was ending operation and expecting material to resume. Thus, I decided to observe to the best of my ability the behavior of the worker once their activities would stop.

My first source of qualitative data were construction site engineers. Interviewing them provided critical data into how they manage workers, their observation of workers behaviors during hot days, protect mechanisms available to workers, and payment modalities. Following these interviews I engaged with the workers. I developed two different interview guides: one of the site engineers and one for the construction workers. In the interviews, I considered the site engineers as experts who could help provide contextual information on the information received from the construction worker. Given the qualitative approach, the data analysis is interpretative to capture meanings and perspectives. Each interview was recorded and then transcribed. As indicated earlier, each phase of the data collected was separated by a 24-hour break. During these breaks, I processed the data gathered to capture emerging patterns. In detecting patterns, I adopted a color-coding technique. Given the qualitative part of this study is taking place after the quantitative part, I developed the interview guide based on the quantitative study design. Therefore, I organized the data collected per the variables in the quantitative analysis.

4.5.6. Research Ethics

In order to abide by the research ethics standards, I completed a research ethics course, and received approval from the Institutional Review Board (IRB) before proceeding with the research. The graduate students who contributed in interpreting the interviews all also completed the research ethics training and received a certificate of completion. During the research, a consent form was orally administered to the interviewees and the data is stored in a locked file to which only me have access. In the data analysis, I use pseudonyms instead of names, as per the requirements of the Institutional Review Board (IRB).

4.6. Study Limitations

The only limitation of this study is my limited linguistic ability in Arabic. My initial aim was about 20 interviews to collect a rich set of data and better immerse the quantitative results in the context over a wide scope. To mitigate this limitation, I reduced the scope of the study as well as the variables. This reduction in scope allowed me to reach data saturation early during the fieldwork.

Chapter Five: Empirical Results

"Discover the laws of the phenomenon being studied, discover relationships between the different elements, their modifications, and evolutions" Henri Lefebvre (2012).

The econometric modeling and analysis, the qualitative design and all interviews conducted all aimed at understanding the laws, the mechanisms and relationships between different factors affecting vulnerability to poverty. This chapter provides the findings discovered as a result of the data analysis. In this chapter, I engage in a dialogue between the quantitative results, the qualitative data, and the literature to present if and how increasing Wet Bult Temperatures (WBT) affect the socioeconomic wellbeing of the construction worker.

5.1. The Econometric Outcome

VARIABLES	(1) Net Wage	(2) Self-Employment Income	(3) Total Food Expenditure	(4) Pharmacy/Medical Expenditure	(5) Health Expenditure
Wet Bulb Temperature	-198.3	-10,249***	-1,509***	-670.0***	-844.1*
	(1,572)	(3,452)	(518.1)	(177.6)	(432.3)
Age Household Head	237.6***	296.7***	96.77***	20.05***	26.73***
	(20.53)	(45.68)	(6.761)	(2.300)	(5.635)
Sex Household Head	27,973***	1,659	7,591***	-557.1	-778.1
	(5,659)	(16,821)	(2,069)	(698.5)	(1,716)
House head Educational Level	2,377***	4,592***	535.7***	70.99***	129.1***
	(182.1)	(398.6)	(58.78)	(20.02)	(49.00)
Dwelling Type	-1.897	2.639	-2.339***	-0.308	-0.355
	(2.255)	(4.986)	(0.768)	(0.262)	(0.641)
Access to Water	-241.6	17.47	-163.7	34.49	-4.447
	(324.0)	(738.1)	(109.6)	(37.58)	(92.23)
Access to Electricity	1,274	-6,041	36.72	287.5	594.1
	(2,116)	(4,740)	(711.3)	(240.2)	(590.0)
Garbage Disposal	-1.098	-7.478***	-0.194	-0.230**	-0.357
	(1.029)	(2.228)	(0.336)	(0.114)	(0.279)
Fridge Ownership	587.4	1,335	977.5***	-5.212	115.7
	(648.9)	(1,524)	(220.6)	(75.19)	(184.4)

Fan Ownership	3,213***	7,854***	1,328***	174.9**	495.0**
	(731.0)	(1,511)	(232.7)	(79.22)	(194.1)
_Iyear_2010	-198.8	3,287	1,711***	719.2***	794.7**
	(1,472)	(3,049)	(465.4)	(158.6)	(387.3)
_Iyear_2015	6,664***	2,485	5,281***	864.1***	1,571***
	(1,012)	(2,107)	(323.2)	(110.3)	(269.2)
_Iregion_2	-849.5	23,293***	3,488***	1,230***	1,255
	(3,224)	(7,142)	(1,057)	(362.2)	(882.5)
_Iregion_3	-5,551	46,884***	8,084***	3,088***	2,973*
	(6,206)	(13,409)	(2,038)	(696.8)	(1,699)
_Iregion_4	-881.2	7,053**	1,747***	-44.11	-226.6
	(1,806)	(3,481)	(560.4)	(189.8)	(465.4)
_Iregion_5	-3,263	-159,777***	-24,362***	-11,088***	-14,497**
	(25,049)	(54,862)	(8,237)	(2,823)	(6,873)
_Iregion_6	-4,411	-158,263***	-25,297***	-11,080***	-14,210**
	(24,970)	(54,911)	(8,215)	(2,815)	(6,854)
_Iregion_11	790.0	28,367**	5,400***	2,121***	2,500*
	(5,292)	(11,824)	(1,754)	(600.5)	(1,463)
_Iregion_12	-1,990	12,922**	1,238	1,131***	1,046
	(2,451)	(5,341)	(801.9)	(274.4)	(668.8)
_Iregion_13	-1,808	5,274	1,195**	270.0	-53.50
	(1,658)	(3,501)	(533.6)	(181.9)	(444.0)
_Iregion_14	-211.2	7,789*	312.0	487.6**	371.0
	(1,865)	(4,200)	(618.1)	(211.3)	(515.0)
_Iregion_15	-3,835	9,489*	1,563*	1,355***	2,238***
	(2,705)	(5,667)	(884.1)	(303.1)	(738.4)
_Iregion_16	-2,784	4,190	782.2	566.3***	436.4
	(1,891)	(4,198)	(624.5)	(213.2)	(520.2)
_Iregion_17	-2,840	14,538**	1,079	843.4***	668.2
	(2,787)	(6,102)	(921.4)	(315.3)	(768.9)
_Iregion_18	-4,517***	5,497*	152.2	139.8	-113.4
	(1,474)	(2,895)	(467.0)	(158.6)	(388.2)
_Iregion_19	-813.0	-4,635	-675.6	-53.11	-625.6*
	(1,371)	(2,976)	(449.3)	(153.3)	(374.6)
_Iregion_21	-1,409	-4,093	-3,096***	-837.2***	-1,485***
	(1,653)	(3,710)	(543.2)	(185.8)	(453.0)
_Iregion_22	-2,976**	-6,656**	-1,266***	-315.8**	-586.1*
	(1,181)	(2,631)	(394.9)	(133.5)	(327.7)
_Iregion_23	-3,123	-11,195**	-2,014***	-1,102***	-1,659***
	(2,069)	(4,451)	(675.1)	(230.5)	(562.6)
_Iregion_24	-3,811	-19,265***	-2,802***	-1,352***	-1,743**
	(2,599)	(5,593)	(855.7)	(292.4)	(713.2)
_Iregion_25	-4,258	-23,440***	-4,599***	-1,415***	-2,139***
	(2,737)	(6,116)	(902.5)	(308.8)	(752.9)
_Iregion_26	-5,031*	-21,559***	-4,076***	-1,400***	-1,953***
	(2,662)	(5,786)	(875.2)	(299.6)	(729.8)

_Iregion_27	-4,422**	-18,026***	-3,059***	-1,044***	-1,666***
	(2,048)	(4,534)	(682.2)	(233.4)	(570.0)
_Iregion_28	-5,274	-23,679***	-4,934***	-1,899***	-2,731***
	(3,356)	(7,229)	(1,101)	(377.7)	(917.6)
_Iregion_29	-5,835***	-9,604**	-1,567**	-1,147***	-1,900***
	(2,158)	(4,775)	(688.9)	(236.8)	(572.5)
_Iregion_31	-1,537	-40,393**	-5,591**	-3,351***	-4,257**
	(7,841)	(16,477)	(2,503)	(856.1)	(2,086)
_Iregion_32	-11,412*	25,497**	3,636*	1,461**	1,635
	(6,153)	(11,522)	(1,960)	(693.9)	(1,697)
_Iregion_33	-3,574	19,862***	-35.27	-338.8	-1,315*
	(2,725)	(5,466)	(852.0)	(310.2)	(732.2)
_Iregion_34	11,346	-24,733	-5,191*	-3,972***	-3,566
	(8,587)	(18,279)	(2,748)	(959.4)	(2,338)
_Iregion_35	51,829**	-147,211***	-14,749*	-11,162***	-14,909**
	(24,795)	(53,992)	(8,114)	(2,788)	(6,791)
Constant	-25,545	151,036***	18,019**	10,138***	12,914*
	(24,484)	(54,796)	(8,110)	(2,777)	(6,763)
Observations	2,535	1,638	3,176	3,132	3,146
R-squared	0.322	0.262	0.445	0.135	0.087

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5:[2] Regression Output: The effect of WBT on the Socioeconomic Well-being of construction workers in Egypt (Source: Constructed by the author on STATA using 2008, 2010, and 2015 HIECS on Egypt and Meteorological Data from NASA Power Project)[3]

5.2. Interpreting the econometric results through a contextual lens

Extent literature highlights that climate change-induced extreme weather events are set to worsen poverty and inequality among countries, within countries and various socioeconomic groups (Dow, 1992; Stern, 2007, Ullah et al., 2017; Bellon & Massetti, 2022). Further studies highlighted that precarious workers, including construction workers, are the most vulnerable to extreme weather events (Chiba et al., 2017; Raymond et al., 2020; Narocki, 2021; Das, 2015). The literature informed the hypothesis which guided this study. Findings from Table 5 confirm

[2] Regression outputs using the wage and self-employment adjusted to CPI income are accessible in the Appendix
[3] Table 5 shows the effect of the WBT on net wage, self-employment income, food and health expenditure.

and reject some of the hypotheses formulated earlier. The findings from the econometric model are at a 95% significance level.

5.2.1. Hypothesis 1: Increased wet bulb temperature decreases the net wage of construction workers' households in Egypt.

Studies by Orlov et al., (2019) and Das (2015) in India concluded that increasing WBT contributed to reducing the income of construction workers. In their studies, no major separation occurred between the types of workers. Outcome from the econometric model in Table 5 shows an insignificant effect of increased WBT on the wages in construction workers' households. This is contrary to the literature. While there is a negative effect, it remains insignificant to be noted. Furthermore, when the waged income is adjusted to the CPI, the results remain insignificant.

The negative result aligns with the data from the qualitative study. On the field, contrary to the general belief, construction workers have contracts, even those specialized in breaking walls. The rationale behind the effect of WBT on wages stems from the belief that increased WBT affects workers' health and productivity (ILO, 2019). Consequently, this would affect their wages (Das; 2015). Contrary to other contexts, in Egypt precarious workers with a contract have wages. During the field work I access key data on how the construction sector is structured. The industry is structured in such a way that there is a major contractor who strikes a deal with a subcontractor. Usually, the subcontractor has an understanding of workers and deploys the staff on the field to work with a site engineer. Consequently, the workers with a contract are directly paid by the subcontractor based on the contract. Construction workers in Egypt, according to the data collected during the interviews, are on three different pay schemes: Daily payments range between EGP 250 - 300. This is usually for low-skilled workers who just carry bricks, the sand,

and break walls. Workers paid based on performance receive between EGP 50 – 100 per meter square. This scheme is usually for those with higher skills such as brick layers, and masters in setting up tiles/ceramic/marble floors and other decorations. This administrative structure protects the worker even when their performance is low, especially due to extreme temperature conditions. Engineer 1 stressed the following when I inquired about the effect of heat on income:

"*In the case you are working with the company (the subcontractor) you have a salary, and it's even possible that you have days off. Even if you are sick, you will be paid. When the weather is extremely hot, they cannot work very well and I accept that. I know the weather is very hot and I know they cannot work very well. In this case I let them free. Whatever they can do I accept it so I am very flexible. They still get the same amount of pay. This is about me as I told you I don't know about other engineers*." Engineer 1, February 2024.

The observation from Engineer 1 who is managing 6 workers on an active construction site is also the same as Engineer 2 who is managing 30 workers. Engineer 2 highlighted the following when I also inquired about the wages of his workers during very hot days.

"It depends. But they work with an external contractor who pays them daily. So long as the worker is working permanently with the contractor, they have a contract and they are taken care of until they can feel better if they are sick. Currently, all my workers have a contract. There is some form of documentation between the worker and the contractor. So, if any of the parties violates the agreement then one party can disrupt the contract. Even when the heat is very high, they get paid, and they are even compensated when there is a drop in productivity." Engineer 2, February 2024.

Both Engineer 1 and 2 provided critical data that explains why construction workers with wages may not be affected by increased WBT. However, it must be noted that while some of the workers have contracts, their employments are irregular, out of formal establishments, and precarious (Assaad et al., 2019; El Ehwany, 2009). During an interview with a construction worker, we recorded the following:

"*During the summer, even when the weather is extremely hot, I still get paid my money at the end of the day. Sometimes I also work per meter square*." Construction worker 5, February 2024.

Based on the above, it appears that the wages of the construction worker having a contract are not affected by increased WBT. Both the quantitative and qualitative data align in that regard.

5.2.2. Hypothesis 2: Increased wet bulb temperature decreases the self-employment income of construction workers households in Egypt.

The results from Table 5 show a negative and strong effect of increased WBT on self-employment income. This suggests that increased WBT negatively affects the income of a self-employed construction worker's households. A marginal increase of the WBT in a given year contributed to a loss of about 10,249 Egyptian Pounds to a self-employed construction worker annually. When self-employment income is adjusted to the CPI, the income loss is 12,791 Egyptian Pound annually (Table in the Appendix). Self-employment income represents the revenue of construction workers who are self-employed on their own account. Consequently, these workers do not have a contract and are not bound by contractual obligations. This category of workers, contrary to those with a contract feel the effect of increased WBT on their productivity just as the waged worker. The difference is that this category of worker pays for the loss of productivity as highlighted below:

“*We are paid by task completion. We are paid the amount of work we do for a specific task during a specific period. If we complete 50% of the job, we are paid 50%. During the summer, we get tired fast and it affects our income. So, we prefer working at night because of the heat during the summer. But it is not really allowed.”* Construction worker 6, February 2024, February, 2024.

Another interviewee highlighted the following:

“It happens to others that they get very tired and, in this situation, they will leave for the day and they will be paid only for the part that they did and someone else will do the remaining part. At times if they have children, they will ask their children to come and help them. But this is if they have children.” Construction worker 5, February, 2024.

The reality displayed by the interviewees suggests increasing temperatures make them more tired, and this often delays the completion of takes. According to Venugopal et al., (2016) and Narocki, (2021), outdoor workers are vulnerable to heat stress and this could affect income loss due to decreased productivity, particularly among workers with daily targets. The reality displayed by the workers shows that beyond the worker, their children may be involved. While this finding is singular, it raises questions about the intergenerational effects of WBT on poverty.

Engineer 1 provides further clarifications on the mechanisms of pay to freelance workers during periods of extreme heat.

"*If you are freelance, there is no sick pay or leave. If the freelancer is sick and does not come to work, he will not be paid since he is working daily. During very hot days, I make a deal with the freelancer. So, if he's not able to do enough work that is not on me. When the freelancer makes a deal with me, he knows the weather, he is conscious of the world, and he knows that the work will take one or two, three or four days so I usually pay for this. So, he knows how many days he will take for that work. He knows the deal, he knows the weather, his not crazy or a kid.*"

Engineer 1, February, 2024.

The foregoing suggests that while the worker with a contract is protected from the negative effects of WBT temperatures, the freelance worker is not. Consequently, the buffers in a contract that limit the effect of WBT temperatures on the contract worker do not exist for the freelance worker.

The risk of job loss and the opportunity cost of getting other jobs

The effect of WBT on freelance workers has an impact beyond their income but also affects and threatens their current jobs. Interviewees stressed their ability to adapt and bear the heat or not could affect their job and by extension the pay. One of the workers highlighted the following:

"If someone is frequently unable to work under the hot weather, we will not recruit him again. He is advised to find another job that can fit his ability to bear the hot weather. It happened to me before because I could not bear the hot weather and I was extremely sad to leave and I could not get the compensation that I was supposed to get and this affected my family." Construction worker 5, February, 2024.

Another interviewee also stressed during a dyad interview that:

"When the heat is high it will affect us and our income. Some workers cannot even show up, or even finish half a day. In this case, they are not paid. It has not happened to me but I know some people in this situation. It affects them significantly because they are married." Construction worker 7, February 2024, February, 2024.

The foregoing suggests that extreme climatic conditions affect the income of self-employed construction workers who are already working. In some other instances, they may lose their jobs for lack of adaptation to the difficult weather, or not even show up. These are critical elements that affect the income of the self-employed construction worker.

During the data collection phase, I engaged in an observation/tracking phase of two workers whose sites had stopped operations. Both of them identified as freelance workers who are paid daily. Therefore, once activities on their construction site paused, for more materials, I sought to know what they would do. In a week, I recorded them working on two different construction sites. On the last site where I recorded their presence, they were working on the site of Engineer 2 at night when the official workers, on contract, had already left. The two tracked freelance workers were working at night, carrying bricks. They had a task to complete and this was being done at night. In the summer, and particularly with high WBT, decreased productivity means the workers spend longer hours on a specific task. This limits their speed of task completion and does not allow them to move to other jobs to increase their income.

The data collected also suggest an intergenerational effect of WBT among freelance construction workers. Years of experience has proven to be key. Most of the workers have over 10 years of experience in the sector, therefore, they at times relate the experiences of others who have been affected by increased temperatures. However, one worker highlighted a critical element as stressed below:

"When the temperature is high, productivity is higher than during the winter and we are happy to work as much as possible and as long as it takes because this gets us more income yes we get a bit tired we get a bit thirsty especially when we are working on the roof. But we work for longer hours. We got use to the heat we have adapted. So, the young ones who cannot tolerate the heat would leave and we would do their work on extra and get extra pay. So usually when I finish my main job, I am paid for what I finish. and when I do extra work, I get more pay."

Construction worker 5, February, 2024.

These intergenerational dynamics may suggest that construction workers with low experience might not have developed adaptation mechanisms as the older ones. Thus, younger construction workers may record a higher effect on their income compared to more experience ones.

The analysis under this hypothesis suggests the strong effect of increasing WBT on the income of self-employed construction workers. The findings align with studies by Venugopal et al., (2016) and Narocki, (2021), and the ILO (2019). The econometric results here considered current income from self-employed workers. However, even after adjusting the income of both waged workers and self-employed workers to the CPI to account for inflation, the results were the same in terms of sign and significance: Hypothesis 1 is rejected and hypothesis 2 is confirmed. Thus, with or without inflation, with or without currency devaluation, WBT has a negative and significant effect on self-employed construction workers' income.

5.2.3. Analyzing Hypothesis 1 and 2 through graphs

While primary data provided critical information, I proceeded further to mine data and draw insights through a thorough study of income trends among the waged and self-employed workers both on the current value of the income and the adjusted CPI value of the income. A trend analysis of the mean wages of construction workers shows an upward trend as displayed in Figure 9.

Figure 9: *Trend analysis of mean net wage and self-employment income (Source: Constructed by the author using 1999. 2004, 2008, 2010, 2015, 2017, and 2019 HIECS on Egypt)*

Figure 9 shows the evolution of mean wages and self-employment income among construction workers from 1999 to 2019. Since 1999, while both groups' income increased jointly, it appears that in 2010 when Egypt recorded its first spike in WBT, the group with the net wage saw their income increase faster while self-employed workers recorded decreased income. Furthermore, in 2015 and 2017, Egypt recorded a spike in WBT of 13.40 and 13.33 respectively. In 2015, the income of the waged construction worker also increased faster than that of the self-employed worker. To verify the observation from Figure 9, a second layer of the analysis further captures mean income adjusted to the CPI. Figure 10 shows a trend of mean income adjusted to the CPI.

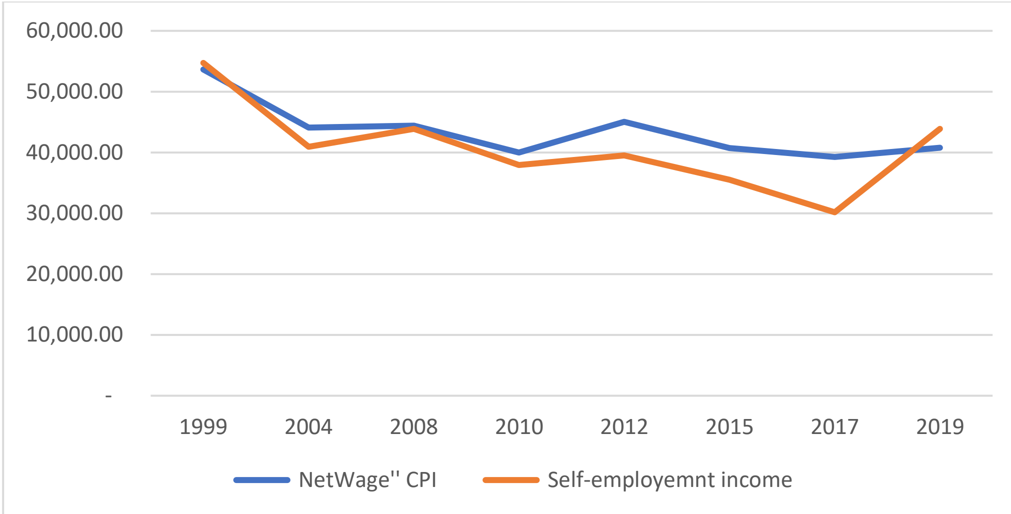

Figure 10: *Trend analysis of mean net wage and self-employment income adjusted to CPI (Source: Constructed by the author using 1999. 2004, 2008, 2010, 2015, 2017, and 2019 HIECS and World Bank CPI on Egypt).*

Contrary to Figure 9 which shows an increasing income of the construction worker, an adjustment of income to CPI shows that in reality, the income of the construction worker is decreasing. Of particular interest in this figure are the years 2008, 2010, and 2015. In 2008, as per figure 4, Egypt recorded a low WBT temperature of 12.83. In this year, both the construction worker on wage, and the self-employed earn similar income. However, in 2010, when Egypt recorded its first-ever annual spike in WBT the income of the self-employed worker decreased faster than the income of the waged worker. Although the income of the waged worker decreased from 2010, in 2015 again when Egypt recorded a pick in the WBT, while the income of the waged worker stabilized, the income of the self-employed worker further decreased. The dynamics observed may suggest that since the waged worker is on contract, he is more protected than the self-employed worker who may not have financial buffers once they lose productivity. The analysis so far supports the argument that WBT affects more the self-employed worker compared to the worker with a contract. A third layer of the analysis through a combo chart merges the WBT and income based on CPI values as displayed in Figure 11 and 12.

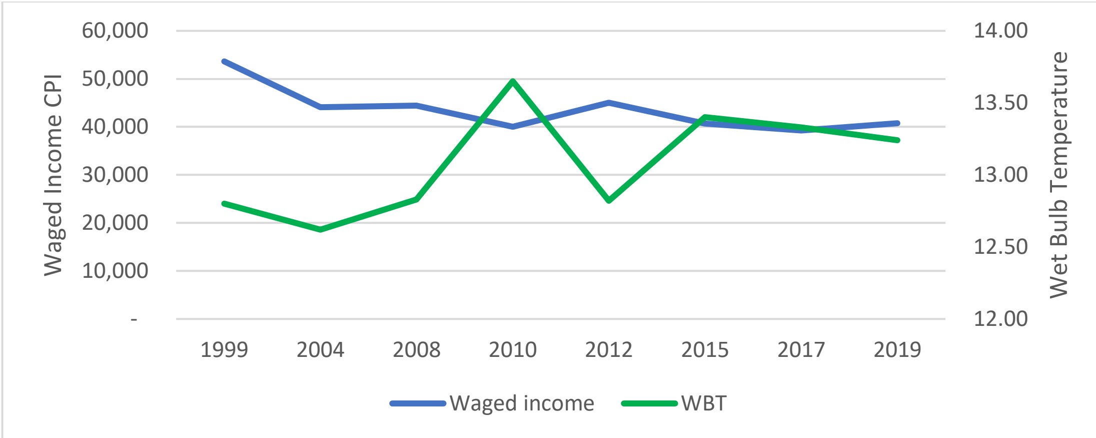

Figure 11: *Combo chart of trend analysis of mean net wage adjusted to CPI and WBT (Source: Constructed by the author using 1999, 2004, 2008, 2010, 2015, 2017, and 2019 HIECS on Egypt, CPI data from the World Bank, and Meteorological Data from NASA Power Project)*

Figure 12: *Combo chart of trend analysis of mean self-employment income adjusted to CPI and WBT (Source: Constructed by the author using 1999, 2004, 2008, 2010, 2015, 2017, and 2019 HIECS on Egypt, CPI data from the World Bank, and Meteorological Data from NASA)*

A thorough observation of Figure 11 and 12 shows that in 2010, when Egypt recorded a high WBT, the self-employed workers' income (Figure 12) decreased faster than the waged workers' income (Figure 11). From 2015 to 2019, as the WBT remained high. While the mean income of the self-employed worker drastically decreased (Figure 12), the income of the waged worker remained stable (Figure 11). Thus, regardless of variations on the WBT, the waged worker remained protected while the "freelancer" witnessed significant income reduction.

5.2.4. Hypothesis 3: Increased wet bulb temperature decreases total food consumption among construction workers' households.

Studies on poverty usually consider household food consumption. In my analysis, I consider both income and food consumption (Baquie & Fuje, 2020; Brown et al., 2022). General literature suggests climate change could reduce food consumption and lead to malnutrition among precarious workers (Stern, 2007; Waha et al., 2017; UNDP/MPED, 2021). Another rational stress is that decreased income among low-income workers can negatively affect their food consumption. The effect of shocks on household food consumption allows a better estimation of vulnerability to poverty. The econometric result in Table 5 shows that WBT has a negative and significant effect on the household's total food expenditure regardless the employment category of construction workers (Waged or Self-employed). This suggest that a marginal increase by one degree of the WBT would result into a reduction of Total Food Expenditure by 1509 Egyptian Pounds annually. The data collected via interviews further stressed this fact, particularly regarding financial resource allocation as highlighted by a construction worker who related his personal story in the following:

"During the summer, especially when the day is very hot, we buy the water in the supermarket it is very expensive because it is in the supermarket however, we always need cold water. This makes us spend a lot. We also buy other drinks which have a lot of sugar also lemon drinks. These expenses reduce our income. During the summer, most of the expenses will go to the supermarket at my level and this will decrease the money that my family will use. During the winter the expenses increase more on food and chicken meanwhile in the summer we are not

able to buy a lot more meat because half of the expenses go to the drinks that we buy." Construction worker 4, February 2024.

During one of the focus group discussions, one of the participants further stressed the following:

"*Food costs us more in summer. It is difficult to allocate money for food. Because we need to buy soft drinks or something cold. So eventually we need to spend. But during the winter we can eat food available*." Construction worker 7, February 2024.

Most of the interviewees made the comparison between Summer and Winter due to the challenge of pinpointing or remembering the exact effect of WBT on household expenditures on a specific day. Both the quantitative and qualitative results align in stressing that increased WBT contributes to decreasing the total food expenditure of construction workers' households. The effect of WBT on household food consumption is not direct. The construction workers' adaption mechanism, necessary for them to continue working, is the cause. Since the workers' income is fixed, their expenses in purchasing soft drinks reduce their income allocated to household food expenditure. The workers can exactly note the difference between the food expenditure, and quality during the summer compared to the winter. Beyond the adaptation expenses on the construction site, at home, the construction worker needs to adapt to the increasing temperatures. All the interviewees stressed that during very hot days, they need cold water at home, and need to store their food in the fridge. Thus, having a fridge is a must. All the workers have indicated they have a fridge and a fan. However, they also indicated that increased electricity bills reduce their income as highlighted below:

"*Yes! Electricity bills also increase and of course, this also affects us. When we don't have a fridge, we buy ice to be able to get cold water. When we don't have a fridge, we cook every day* *because the food spoils very fast. And this is also expensive to cook every day. Plus, the prices increase every day so I am not able to save money on the daily situation*." Construction worker 2, February 2024.

According to Das, (2015), and Narocki, (2021) increased temperatures force workers to borrow money to purchase adaptation gadgets such as fans, and a fridge. However, they did not study how these purchases effects on electricity may affect the income of the workers. In this study, it appears the worker know, and feels the effect of their adaptation.

The Workers' Inability to Save

Saving is critical to allow low-income groups to climb the social ladder, access to liquidity, investment (Sherraden & McBride, 2010). Therefore, I extended the scope of the study to understand if and how construction workers save money. Some of the interviewed workers stressed they save while others underlined their inability to save. Among those that save, this is seasonal as indicated by the following:

"It depends usually whether it is the summer or the winter so my saving patterns depends on that. It is not fixed and I cannot specify how much I save because in the winter for example I mostly spend about EGP 100 in the day but during the summer I can spend 150 pounds so usually in the winter I'm able to save EGP 50." Construction worker 5, February 2024.

One of the participants of a focus group discussion stressed the following: *"It is not always the same amount between winter and summer. It depends on the frequency of work. So, I cannot give a specific amount or regular amount".* Construction worker 7, February 2024.

Despite the inability of the majority of the workers to save, those who do can understand the difference between their savings in Winter and Summer. They know that given their expenses in summer, they are unable to save. None of the workers has an asset which represents an investment allowing them to increase their income and potentially move from their state of precarity.

5.2.5. Findings from Hypothesis 4 and 5

- **Hypothesis 4: Increased wet bulb temperature increases Pharmaceutical/Medical Expenses among construction workers' households.**
- **Hypothesis 5: Increased wet bulb temperature increases health expenditure among construction workers' households.**

The aim of the hypothesis on health expenditure sought to analyze and capture the potential effect of extreme temperature on construction workers. Researchers highlighted the detrimental effects of WBT on the health outcomes of construction workers (Raymond et al., 2020; Chow, 2022). The assumption is that increased negative effects of WBT on health would contribute to increased health expenditure (Anderson, 2010; Nunfam et al., 2019). However, in my econometric model, the result in Table 5 shows a negative effect of WBT on construction workers' health expenditures both in hospitals and at the pharmacy. According to the econometric results, a marginal increase of the WBT contributes to an annual reduction of Pharmacy/Medical Expenditure by 670 Egyptian Pounds and a reduction of health expenditure by 844 Egyptian pounds. The outcome rejects the hypothesis that WBT may induce increased expenditure on health.

To understand this result which is contradictory to extant literature, I inquired about health during the interviews with construction workers. Most of them highlighted that they do not get sick since they have adapted. "*There is a lot of sweat and this does not allow us to work very well and also we feel very tired but we don't fall sick*" Construction worker 2, February 2024. Another interviewee stressed their adaptation "*There is no difference because we have adapted to the work. The tiredness, the difficulties, everything. We have adapted."* Construction worker 3, February 2024.

It appears the construction workers are not falling sick as predicted by other literature. This could be due to their level of experience or rather, due to their level of precarity or need for cash, the workers may disregard health, abuse their bodies, and consider falling ill as a result of heat to be a luxury. All the interviewed workers have at least 13 years of experience. This means they have adapted. This point is also related to the intergeneration gap in effect. While the younger workers may leave the site, the older workers may stay. Site engineers are also able to help the worker adapt better as stressed in the following:

"Workers take precautions so they take lots of water. There is no much behavior change. There are risks under extreme heat. But they take precautions and we stay under ceilings and roofs. But in cases we are not under ceilings or roofs things can gets complicated. There are instances when workers get tired and they leave. But also, when there is extreme heat we watch TV, and we take precautions." Engineer 2, February, 2024.

Most of the workers, just like the Engineer stressed indicated they could work under any condition. However, their ability, adaptation, and willingness to work as *"slaves"* might be triggered by their condition of precarity. During a dyad interview, two workers started an argument as related here:

"- Who would work under hot weather? 45 degrees? Not me."

"- Yes true. You can afford not to work. You are single. But I have a wife and two children. No matter the heat I will continue working if not I cannot feed my family. I am ready to work 48 hours. Only God help me." Dyad dialogue, February 2024.

This argument, which continued even after I left the site expresses the fact that even if the construction worker were to fall sick, as long as the disease is not dangerous, they may continue working and disregard their health conditions.

5.2.6. Towards a visualization of WBT effects in generating a poverty trap

Based on the findings from both the quantitative and qualitative data, increased WBT negatively affects income among self-employed workers and household food expenditure. In Figure 13, I show how the effect of the WBT, based on data collected can trap the construction worker in poverty. This figure focuses on the self-employed construction worker given the rich data available.

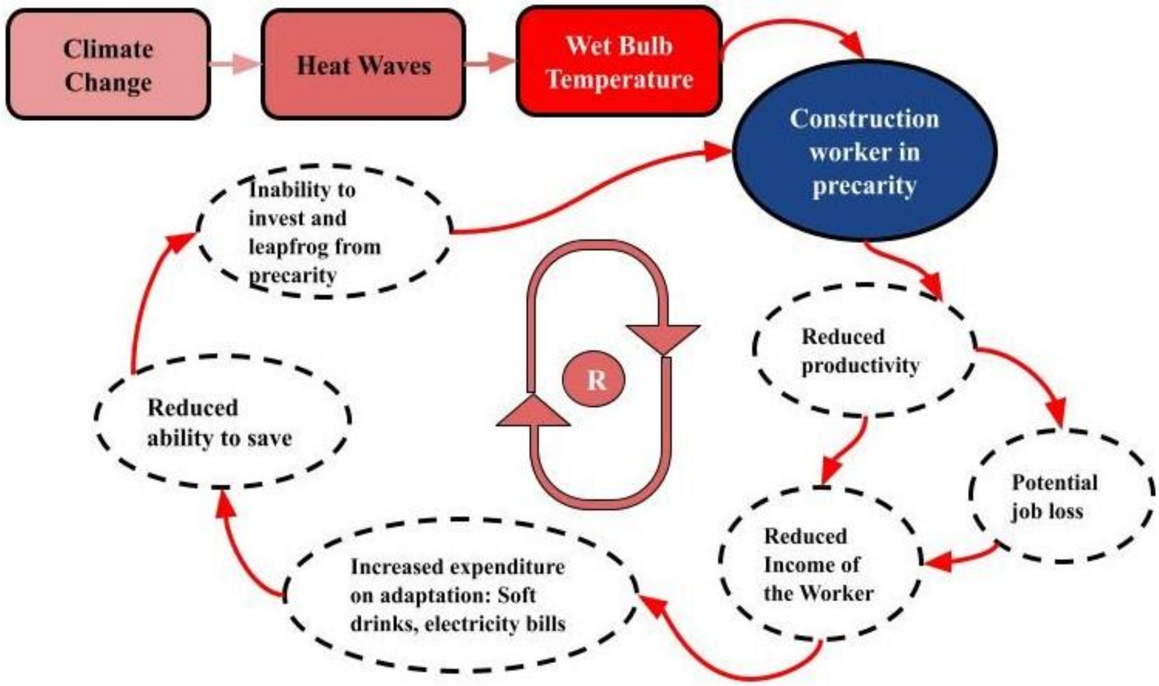

Figure 13: *Poverty Feedback Loop of the self-employed construction worker (Source: Author)*

Figure 13 summarizes the data collected and displays how climate change may lock the construction worker in a state of precarity. WBT affects the construction worker by reducing their productivity. The potential effect of reduced productivity is income loss or job loss. These consequences contribute to reducing the income of the construction worker. While income reduces, the worker also faces increased expenditure both on the construction site and at home to adapt. These effects reduce the worker's ability to save and invest. The worker is found in a perpetual self-enforcing cycle that does not allow them to move from their state of precarity. Therefore, the cycle is Reinforcing (R) itself.

Chapter Six: Conclusion and Policy Recommendation

The planet is getting more and more hot and this reality is no more fictional. Some people on the planet are already feeling the heat. The plethoric number of conferences, and talks, including news bulletins, highlighting the potential and already devastating effect of climate change on human lives are numerous. It is known and the explanation is logical that climate change will make low-income workers poorer. The motivation for this study stems from understanding how low-income workers in sectors, unlike agriculture, are affected by climate change. Based on a mixed method approach, this study provides both macro and micro understandings of exactly how climate-induced extreme weather conditions trap construction workers in poverty.

This study shows that when discussing the impact of climate change on wages loss among precarious workers, there are some nuances to consider. Both the quantitative and qualitative findings align in showing that while the increased WBT does not affect the income of the waged worker, though they remain precarious, self-employed workers' incomes are considerably affected by the WBT. The econometric results show that self-employed construction worker lose about 10,249 Egyptian Pounds with a marginal increase of the WBT by 1 degree annually. When self-employment income is adjusted to the CPI, the income loss is 12,791 Egyptian Pound annually (Table in the Appendix). These findings may suggest that the self-employed worker is more likely to remain locked in a poverty cycle compared to the waged workers. Findings from the study show that regardless the income category (either self-employed or waged worker) there is a significant relationship between increased WBT and reduced food expenditure. The econometric model suggests that a marginal increase by one degree of the WBT would result into a reduction of Total Food Expenditure by 1509 Egyptian Pounds annually. This suggest that increased WBT has a significant effect in increasing poverty among construction workers.

However, contrary to the literature, this study finds that construction workers health expenditure is not affected by the increased WBT. While the literature stressed a positive and significant relationship between increased WBT and increased health expenditure, findings in this study shows a negative and significant relationship. Both the econometric results and qualitative findings align. In a nutshell, the precarious worker in construction remains vulnerable to poverty. However, the self-employed worker is more vulnerable than the waged worker.

6.1. Policy Recommendations

Beyond the motivation to bridge the literature gap, this study sought to fuel discussions on how to support groups that are most affected by climate change. While we must open our hands to our brothers and sisters as the lord commended, we should know how and when. Policy alternatives abound, however, there are four critical policy recommendations as captured in the following:

- **The government should undertake efforts to ensure a contract for construction workers and formalize the sector as a form of social policy:**

The self-employed workers throughout the interviews highlighted the difference between them, and the other workers who have a contract. They understand how dangerous their work is, how vulnerable they are, and the extent to which a contract may be beneficial in improving their socioeconomic well-being. After asking for God's help, the workers called for a contact. Formalizing the status of self-employed workers will allow them to enjoy certain rights, reduce their level of precarity, and contribute to improving their socioeconomic well-being in the face of the detrimental effects of climate change. According to ILO, (2018) having a contract would allow the precarious worker to enjoy some benefits that have the potential to protect and allow them the climb the social ladder. In agriculture, the emergence and increased adoption of contract farming, although do not completely protect farmers, allows them to have predictability in income and market availability. Further emergence of climate insurance schemes for farmers has the potential of protecting them better. While some workers may have a contract, there remain many self-employed workers who are faced with the challenges identified in this study. The government should also invest such energy to improve the socio-economic well-being of construction workers. The Ministry of Social Solidarity (MOSS) should lead this policy option as part of its effort in reducing informality through a form of collective bargain agreement between the government, private contractors, and construction workers representatives to guarantees some minimum standards that can protect the workers' socioeconomic wellbeing in the advent of shocks regardless of their employment status. This approach was adopted through a social dialogue in Germany, Denmark, and Slovania to improve the socio-economic standards of precarious workers (Grimshaw et al., 2016). Adopting this measure would further facilitate efforts by the Ministry of Social Solidarity (MOSS) in formalizing the status of self-employed workers. The MOSS can engage with the Egyptian Federation of Construction and Building Contractors (EFCBC), and enforce labor law 12/2003 which prohibits employers from hiring workers without working permits to construction workers. This will ensure that workers are registered and can both benefit from, and contribute to social insurance.

- **The government should alleviate the cost of electricity as a form of targeted social policy:**

One of the major expense construction workers are confronted with is that of their coping mechanisms. They have all indicated during the interviews an increase in electricity bills. Although water bills may increase, it is marginal compared to electricity bills. As indicated in

Figure 13, an increase in electricity bills further reduces the disposable income of the construction worker and limits their ability to save. During the COVID-19 pandemic in Ghana, the government adopted a targeted measure to make electricity and water free for households whose consumption is within a stated threshold (Dapaah, 2020). The policy aimed to support low-income households, most of whom were financially affected by the pandemic. The Egyptian government could reduce the cost of electricity by a percentage in targeted households based on their consumption to allow the workers to improve their conditions. This measure would further free up some cash that construction workers could allocate adequately to other activities to adapt better to the changing climate or save to invest in revenue-generating activities which could potentially allow them to create buffers to shocks, and invest in assets or livestock to climb the social ladder. In Figure 14, I set the scenarios on how the two recommendations could contribute to breaking the poverty cycle of the construction worker.

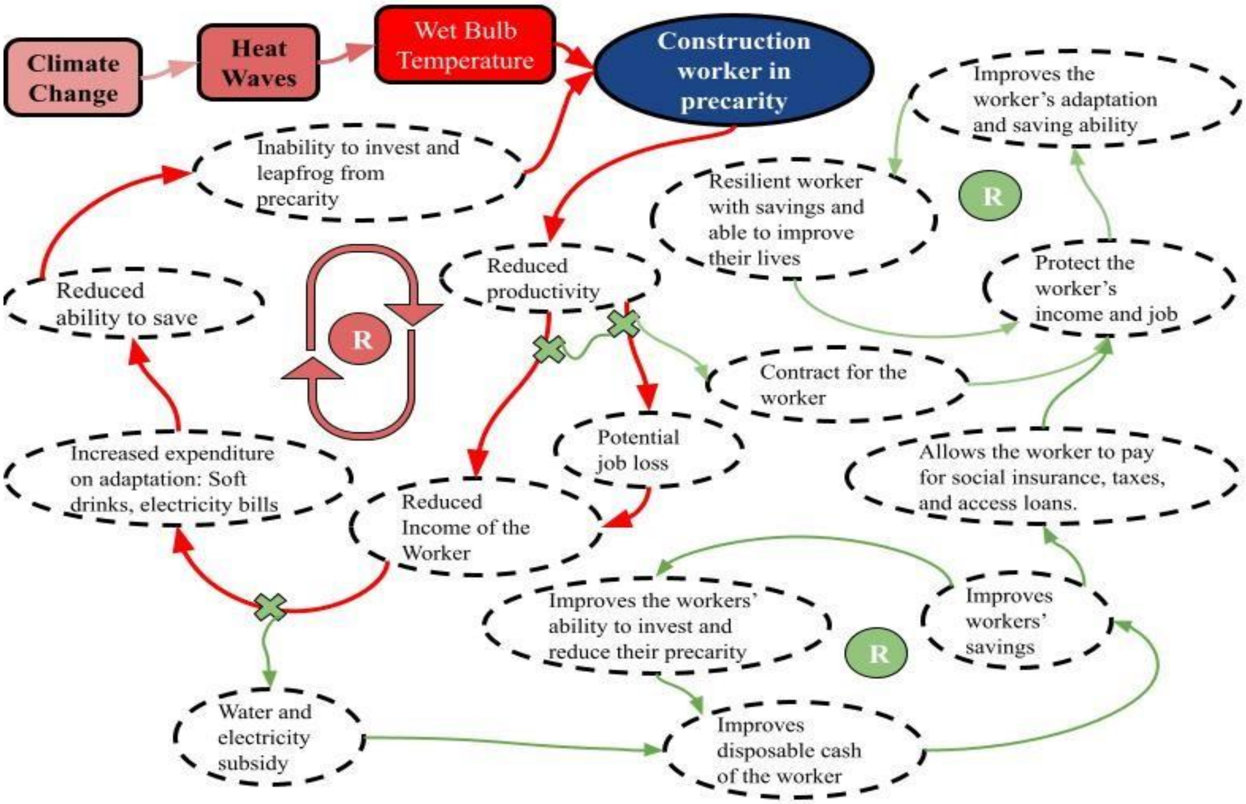

Figure 14: *Scenarios on breaking the poverty cycle (Source: Author)*

Figure 14 displays a visualization of where and how to break the vicious cycle in which the construction worker is found. The break points are marked with a green cross and lead to a virtuous cycle marked by green arrows. The first breaks of the cycle could be enabled through contracts for the construction workers. This would protect them in case there is a drop in their productivity, fall sick, or cannot bear the heat during high WBT. This protection will enable the worker to be more resilient, enable savings, and further allow them to better protect themselves and consequently perform better and secure their income. The second break point is at the level of increased bills. A policy subsidizing the cost of the water and electricity during the summer would improve the construction workers' disposable income. Through a structured intervention by the government, a social insurance scheme can be put in place, therefore, the disposable income would allow the workers to contribute to social insurance, and access a retirement plan.

This would also reduce the financial pressure from the government and ensure the sustainability of the support. Furthermore, the disposable income could contribute to improving the savings of the worker, thus allowing them to either access loans, or investing in minor assets to improve their socioeconomic conditions. This scenario, while realistic should be implemented with the full collaboration of industry stakeholders and modified if necessary to fit the context better and protect the construction worker from shocks.

- **The government should operationalize the loss and damage fund in a practical manner:**

Despite the difficult economic context in Egypt, the government has undertaken efforts to support low-income households with social programs such as Takaful and Karama, and food subsidies. However, most of the government programs target the ultra-poor and the use of the Proxy Mean Testing (PMT) excludes construction workers given they own a fridge. While owning a fridge excludes the construction worker from the bracket of the poor, it does not mean they are not poor. The data collected shows that the construction worker is ready to go to great lengths to buy a fridge. While limited resources to the government supports the argument of excluding a certain group from being eligible for social programs, the government should mount a strong advocacy, and lobby effort for the operationalization of the loss and damage fund and allocate these resources toward target social programs. Such funds could finance an insurance program for construction workers, support a subsidy of electricity and water bills during the summer, and finance efforts toward the formalization of construction workers' status. This policy can be led on the international front by the Ministry of International Cooperation (MIC) and the national implementation of defined programs can led by the Ministry of Social Solidarity (MOSS) which could leverage its experience in implementing cash transfer programs.

- **The Construction workers should organize themselves into a Union:** While this study has not engaged in the labor debate, the construction workers, particularly the self-employed ones have demands for which they require the government's attention. In Nigeria, Zambia, India, South Korea, Israel, and the United Kingdom, precarious workers institutionalized their status by creating or strengthening existing labor unions which led negotiations with the private sector and the government to improve their working conditions and socioeconomic wellbeing (Serrano & Xhafa, 2016). Construction workers in Egypt could adopt the same method, and engage the government with one voice. This would further enable them to adopt joint actions, such as strikes, as recorded in India to voice their concerns, and obtain governmental commitments and actions.

6.2. Implications for future research

While this study assesses the effect of climate change on the socioeconomic well-being of construction workers, there remain several pathways for future research. Findings from this study indicate that increased WBT reduces rather increasing the health expenditure of the construction worker. Across the interviews, it appears that while the worker feels tired, he does not fall sick. This is contrary to studies in other contexts (Anderson, 2010; Nunfam et al., 2019). Further investigations could dive into the health risks of WBT among construction workers in Egypt. Did their body evolve physiologically? Are they sick but ignore it? Or do not know that they are abusing their bodies? Rigorous research could excavate critical findings to inform policy.

From this research, we identified that some workers indeed have contracts while others are self-employed. While this research provided more data on the lives of self-employed construction workers, potential research could dive into the lives of workers with contracts. This would enable us to capture more insights into formal contracts for precarious workers and inform the government's approach to formalizing the sector. Conducting an ethnographic study on the construction worker would provide critical data on their lives, their adaptation strategies to the changing climate, and their job hunt.

While this study provides a feedback loop trapping the worker in poverty, further studies could develop system models to forecast the state of the construction worker in the future. This would further inform governmental actions to trigger tailored social policies.

6.3. Concluding Remarks

Can climate change worsen poverty? Yes. Can climate change generate a poverty trap beyond sectors directly dependent on the climate? Yes, in the case of construction workers. This study is an attempt to understand if and how climate change can generate poverty traps. Based on the quantitative and qualitative approaches, I dig into the reality of construction workers to provide an analytically supported insight into how increased WBT affects the income of waged and self-employed construction workers' households, and their food and health expenditure. I highlight internal mechanisms and complex networks of events to tell the story of the construction worker in the face of a warming planet. Can we end poverty? Yes. Is there a way to end it? Yes. This study provides two scenarios which are all grounded in the data collected from fieldwork. These scenarios constitute preliminary approaches to breaking climate-induced precarity and poverty. Unless we take action, we will prove the construction workers right when they said after our dyad interview *"Only God can help us".*

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Appendix

A1. Humans, the Gods, and the Discovery of Climate Change

"*What we do to ourselves brings us most pain,*" said the servant before disclosing the tragedy befallen King Oedipus, who would make painful life decisions instructed by the gods against his interests to end an environmental disaster and save the people of Thebes. Sophocles' tragedy, from 420 BCE, although a mythological and spiritual play used, once upon a time, to rationalize love between a mother and her boy child (Cherry, 2023), has come to crystalize the early awareness of ancient philosophers that humans could contribute to "polluting the land" thus triggering an avalanche of disasters (Wilkinson, 2011; Horvath, 2019; ND Energy, 2021).

Sophocles' works occurred during the same era as the Greek philosopher and ecologist Theophrastus observed that deforestation contributed to changing the climate (Hughes, 1985). While deforestation and drainage caused more cold in the city of Larisa in Thessaly, he would later observe that deforestation created a warmer climate in ancient Philippi. These observations sparked debates about how human activities could change the climate.

In contemporary times, unlike in Oedipus, where we did not know the processes in which the gods engaged to know the truth, scientists have systematically dissected how past and current human activities contributed to changing the climate. Scientific work seeking to understand why the planet was warm and how the ice age ended discovered CO2 trapped heat from the Sun on Earth, and further emissions would trap more heat and warm the planet (Weart, 2009; Thompson, 2019). First discovered by French scientist Joseph Fourier in 1824, other researchers such as Eunice Newton Foote in 1856 and John Tyndal in 1861 would later uncover the heat-trapping potential of CO_2. In 1895, Svante Arrhenius (1895) developed the first-ever human model for estimating climate change and calculating the greenhouse effect.

The debate about climate change would record a significant curve in 1985 when scientists from 29 countries introduced the topic to the policy arena. In October 1985, they called on world leaders to make efforts toward reducing greenhouse gas emissions (WMO, 1985; ISC, 2018). They were ignored (Weart, 2023). In December 1985, Dr. Carl Segan and a group of scientists testified in the United States of America (USA) Congress on greenhouse effects and warned the world about human-made climate change:

> *"The power of human beings to affect, control and change the environment is growing… we have reached a stage where we are capable to make significant changes both intentionally and inadvertently to the global climate and the global ecosystem"* (Sagan, 1985).

Despite the warnings, business continued as usual. Between 2019 and 2021, commercial banks, including those in the Net Zero alliance, funded about 1.5 trillion dollars in the coal industry, one of the most environmentally damaging industries (Carrington, 2021). Before the scientific community in 1985, oil companies in the early 1980s uncovered their products polluted the environment through CO_2 emissions, which would contribute to warming the planet and the "*disappearance of specific ecosystems or habitats*" (Franta, 2018). However, they engaged in misleading plans about climate change (Hiltzik, 2017), manipulating public opinions by consistently funding media campaigns to downplay climate change and financing lobby efforts to stall policy action on curbing CO_2 emissions (Zou & Stelzer, 2017). Such efforts contributed to triggering climate change denials. Today, in the USA, for example, 139 elected officials in

Congress deny climate change and have received about USD 61 million in funding from oil, gas, and coal companies (Drennen & Hardin, 2021).

But what is climate change? How is it manifest in human societies, and how do humans experience it? Above all, why should we care about climate change, and who should care?

A2. Econometric Results Based on CPI Adjusted Net Wage and Self-Employment Income

	(1)	(2)
VARIABLES	Cpi_Wage	Cpi_Self-Employment Income
WetBulbTemperature	1,136	-12,791**
	(2,233)	(5,695)
Age_Household_Head	364.0***	458.6***
	(29.17)	(75.35)
Sex_Household_Head	27,055***	2,587
	(8,038)	(27,749)
Househead_Educational_Level	3,445***	7,051***
	(258.6)	(657.6)
Dwelling_Type	-2.804	2.348
	(3.203)	(8.225)
Access_To_Water	-506.2	-823.6
	(460.2)	(1,218)
Access_to_electricity	941.5	-7,168
	(3,005)	(7,819)
Garbage_Disposal	-2.295	-13.65***
	(1.462)	(3.676)
Fridge_Ownership	1,411	2,951
	(921.7)	(2,515)
Fan_Ownership	7,292***	18,416***
	(1,038)	(2,493)
_Iyear_2010	-8,018***	-6,701
	(2,090)	(5,030)
_Iyear_2015	-9,497***	-18,182***
	(1,437)	(3,475)
_Iregion_2	-4,995	29,854**
	(4,580)	(11,781)
_Iregion_3	-13,571	57,133***
	(8,815)	(22,120)
_Iregion_4	-1,734	11,173*

	(2,565)	(5,742)
_Iregion_5	17,632	-198,517**
	(35,579)	(90,504)
_Iregion_6	16,318	-195,589**
	(35,467)	(90,585)
_Iregion_11	-2,767	34,054*
	(7,517)	(19,506)
_Iregion_12	-6,361*	14,941*
	(3,482)	(8,810)
_Iregion_13	-5,175**	6,049
	(2,355)	(5,775)
_Iregion_14	-1,506	10,035
	(2,649)	(6,929)
_Iregion_15	-8,355**	11,465
	(3,843)	(9,349)
_Iregion_16	-5,171*	4,315
	(2,686)	(6,926)
_Iregion_17	-6,718*	17,244*
	(3,959)	(10,067)
_Iregion_18	-7,655***	5,614
	(2,093)	(4,775)
_Iregion_19	-2,760	-7,851
	(1,948)	(4,910)
_Iregion_21	-201.6	-82.18
	(2,348)	(6,120)
_Iregion_22	-5,347***	-9,426**
	(1,677)	(4,340)
_Iregion_23	-3,490	-13,801*
	(2,938)	(7,343)
_Iregion_24	-3,199	-23,041**
	(3,691)	(9,227)
_Iregion_25	-4,667	-29,345***
	(3,888)	(10,089)
_Iregion_26	-5,354	-26,505***
	(3,781)	(9,545)
_Iregion_27	-4,884*	-24,521***
	(2,910)	(7,480)
_Iregion_28	-5,318	-31,422***
	(4,767)	(11,925)
_Iregion_29	-6,764**	-11,971
	(3,065)	(7,877)
_Iregion_31	5,740	-50,422*
	(11,138)	(27,182)
_Iregion_32	-19,031**	35,588*
	(8,739)	(19,007)
_Iregion_33	-1,788	37,593***

	(3,870)	(9,017)
_Iregion_34	21,257*	-36,025
	(12,197)	(30,154)
_Iregion_35	120,974***	-172,203*
	(35,220)	(89,069)
Constant	-38,624	190,532**
	(34,778)	(90,395)
Observations	2,535	1,638
R-squared	0.272	0.247

Table 6: Regression Output: The effect of WBT on the income of construction workers in Egypt adjusted to inflation using the CPI (Source: Constructed by the author on STATA using 2008, 2010, and 2015 HIECS on Egypt, CPI data from the World Bank, and Meteorological data from the NASA Power Project)