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ASSESSING THE IMPACT OF WAR

on Development in Yemen

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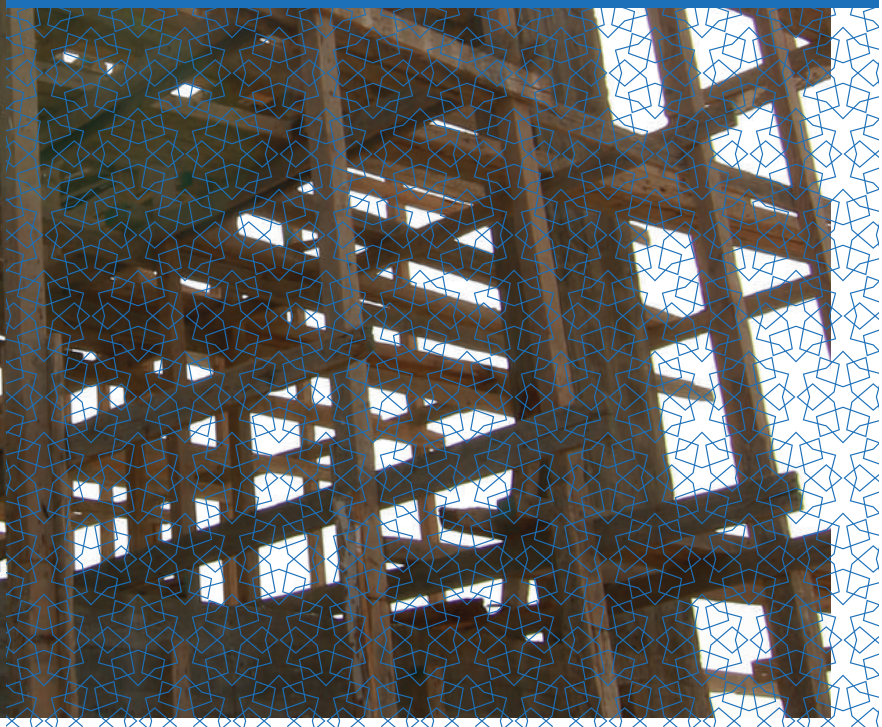
PREFACE

This study on the “Impact of War on Development in Yemen”, was commissioned end of 2018 in collaboration with Frederick S. Pardee Center for International Futures, Josef Korbel School of International Studies, University of Denver. The researchers undertook the analytical work with a desire to understand the impact of war in Yemen across human, social and economic dimensions of development. The analysis was undertaken by calibrating a quantitative modeling system called International Futures (IFs) to fit the available information on the impact of war in Yemen to date, and then create four hypothetical analytical scenarios to be explored. One where the conflict ends in 2019, 2022 and finally one where conflict extents all the way to 2030. To assess the impacts from the conflict across the three conflict scenarios the fourth scenario represents a counter-factual world in which conflict did not escalate beyond 2014. The result is an impact study that quantifies the damages of the war in Yemen across multiple dimension of development such as loss of lives, health, demographics, education, infrastructure and the economy, etc.

The study is intended to advocate to the parties to the conflict on the consequences of the conflict on medium- and long-term development, as recovery to the pre-conflict levels would require two to three generations. At the same time the study intends to inform the general public, including the international community, about the level of devastation caused by the conflict in Yemen, and ask those who have influence over either party to the conflict to urgently push towards a sustainable peace deal and a stop to further escalation. The situation is already extremely severe. If it deteriorates further it will add significantly to prolonged human suffering, retard human development in Yemen, and could further deteriorate regional stability.

EXECUTIVE SUMMARY

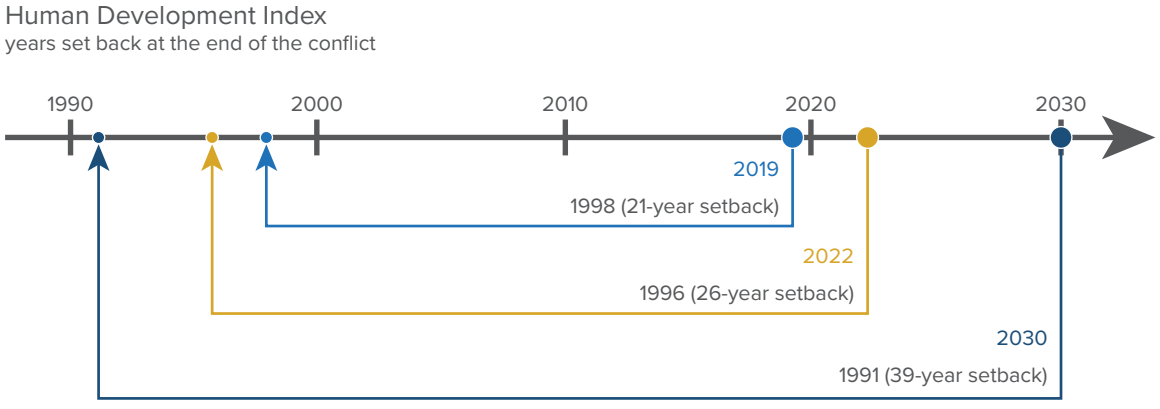


Prior to the escalation of conflict in 2015, development in Yemen was strained. A country of 30 million people, Yemen ranked: (a) 153rd on the Human Development Index (HDI); (b) 138th in extreme poverty; (c) 147th in life expectancy; (d) 172nd in educational attainment; and, (e) was in the World Bank low-middle income category. Projections suggest that Yemen would not have achieved any of the Sustainable Development Goals (SDGs) by 2030 even in the absence of conflict.

The ongoing conflict has further reduced the pace of development. The impacts of conflict in Yemen are devastating—with nearly a quarter of a million people killed directly by fighting and indirectly through lack of access to food, health services, and infrastructure. Of the dead, 60 per cent are children under the age of five. The long-term impacts of conflict are vast and place it among the most destructive conflicts since the end of the Cold War. The conflict has already set back human development by 21 years (Figure 1). If the conflict were to end in 2022, development would be set back 26 years—over one generation. If the conflict persists through 2030, the setback grows to nearly four decades, or more than one-and-a-half generations. In this case, one-in-five surviving Yemenis will be physically stunted because of the conflict.

This report is motivated by a desire to better understand the impact of conflict in Yemen across multiple pathways of human development. We assess this by calibrating the International Futures (IFs) model and using it to create four alternative scenarios. These scenarios reflect three potential pathways of conflict development (ending in 2019, 2022 and 2030), as well as a counterfactual world in which conflict did not escalate after 2014. These scenarios are then used to estimate the impact of conflict on development across multiple issue areas (demographic, economic, education, infrastructure, health, etc.).

FIGURE 1 | *How long does conflict in Yemen set back human development?*



2019 IMPACT

If the conflict were to end in 2019, it would account for:

233,000 DEATHS (0.8 per cent of the 2019 population) with 102,000 combat deaths and 131,000 indirect deaths due to lack of food, health services and infrastructure

1 CHILD DEATH every 11 minutes and 54 seconds in 2019

140,000 deaths of children under the age of five

13.4M YEARS
years of the population living with malnutrition (17 per cent of the total population in 2019)

44M YEARS
of people living in extreme poverty (40 per cent of the 2019 population)

1.6M YEARS
of children living with malnutrition (14 per cent of the 2019 child population)

10.3M YEARS of children without access to schools (36 per cent of school-aged children in 2019)

US $89B
loss in economic output

&

US $2,000 reduction in Gross Domestic Product (GDP) per capita (at Purchasing Power Parity (PPP))

2022 IMPACT

If conflict continues, the cost in mortality, especially the lives of children, will grow. In a scenario that assumes reduced conflict intensity relative to 2018, but continued large-scale violence through 2022, we estimate that fighting will account for:

482,000 DEATHS (1.5 per cent of the 2022 population) with 166,000 combat deaths and 316,000 indirect deaths due to lack of food, health services, and infrastructure

1 CHILD DEATH every 7 minutes in 2022

331,000
deaths of children under the age of five

86.6M YEARS
of people living in extreme poverty (49.4 per cent of the 2022 population)

4.4M YEARS
of children living with malnutrition (24 per cent of the 2022 child population)

&

37.3M YEARS
of the population living with malnutrition (31 per cent of the 2022 population)

21.2M YEARS
of children without access to schools (43 per cent of school-aged children in 2022)

US $181B
in lost economic output

&

US $2,600
reduction in GDP per capita (at PPP)

2030 IMPACT

If the conflict continues through 2030, it will increasingly and disproportionately impact the lives of the youngest:

1.8M DEATHS (4.6 per cent of the 2030 population) with 296,000 people dying directly in conflict and an additional 1.48 million people dying indirectly due to lack of food, health services and infrastructure

1 CHILD DEATH every 2 minutes and 24 seconds in 2019

1,500,000
deaths of children under the age of five

265M YEARS
of people living in extreme poverty (71 per cent of the 2030 population)

22.7M YEARS
of children living with malnutrition (55 per cent of the 2030 child population)

&

220.3M YEARS
of the population living with malnutrition (84 per cent of the 2030 population)

57.4M YEARS
of children without access to schools (48 per cent of school-aged children in 2030)

US $657B
loss in economic output

&

US $4,600
reduction in GDP per capita (at PPP)

The conflict in Yemen is devastating to development gains and disproportionally impacts children. By 2030 we estimate that indirect deaths (caused by lack of access to food, health care and infrastructure services) will be five times greater than direct deaths. Most of those deaths are to infants and children, with an estimated 1.5 million killed by 2030 if conflict persists. Table 1 shows the impact of ending the conflict in 2019, 2022 and 2030 on indicators of development compared with a *No Conflict* scenario.

TABLE 1 | *Summary of results, reporting human development indicators in the last year of the conflict according to each scenario.*

	Scenario	Last year of conflict			
		2014	2019	2022	2030
Direct conflict deaths (cumulative difference)	*Conflict*		102,000	166,000	296,000
Indirect conflict deaths (cumulative difference)	*Conflict*		131,000	316,000	1,484,000
GDP per capita (PPP) *thousand US*	*No Conflict*	3.8	4.0	4.3	5.9
	Conflict	3.8	2.0	1.7	1.3
Extreme poverty* *percent of population*	*No Conflict*	18.8	18.7	15.4	6.6
	Conflict	18.8	58.3	64.8	77.6
Infant mortality *deaths per 1,000 births*	*No Conflict*	46.3	36.7	32.2	21.3
	Conflict	46.3	69.6	81.5	136.6
Malnourished children *percent of children*	*No Conflict*	42.1	36.5	33.5	24.6
	Conflict	42.1	50.5	57.3	79.5

Gross Domestic Product (GDP) per capita, extreme poverty, and malnourished children 2014 data from World Bank World Development Indicators (WDI); infant mortality 2014 data from UNPD World Population Prospects. *Poverty line of US $1.90 a day.

It is difficult to conceptualize the scale of these impacts on development. To better contextualize this, we used quantitative clustering techniques to compare the conflict in Yemen with other conflicts since the end of the Cold War. We discovered that Yemen's current conflict is similar to others that are large, last for a long time and have significant impacts on human development such as Iraq (2003–present), Democratic Republic of Congo (1992–present), Sierra Leone (1991–2002) and Liberia (2000–2003).

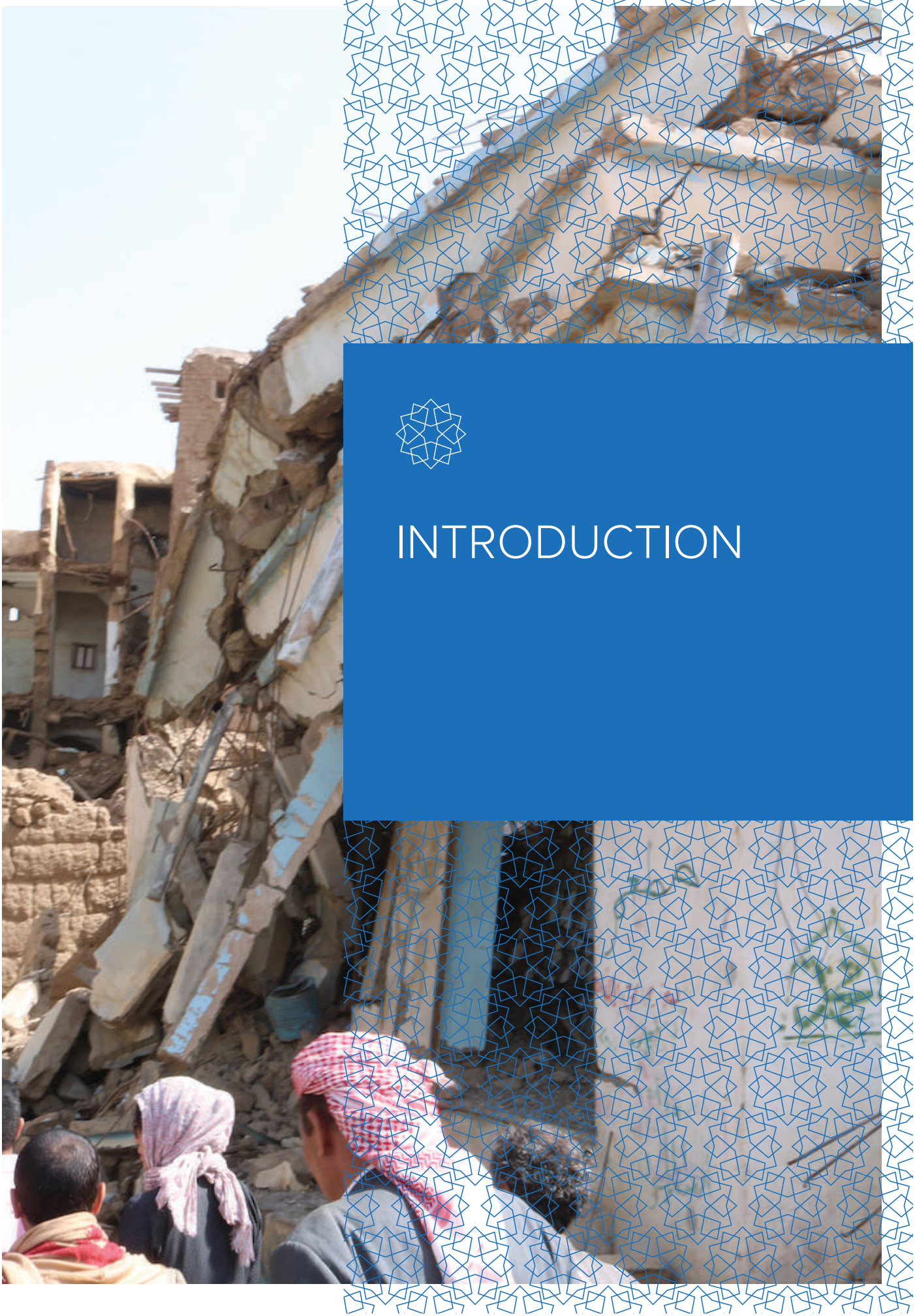
This study has limitations and focuses narrowly on the impact of conflict on development. We do not study the drivers of conflict, unfolding conflict processes or the potential for post-conflict recovery. We project a de-escalation of conflict from 2018-levels (in terms of deaths and impact on the economy) and also make assumptions about how the conflict will unfold through 2030, both of which drive many results.

This report breaks important new ground in presenting a framework for understanding how ongoing conflict impacts human development across multiple dimensions. It builds upon academic work studying the impact of conflict on development, systems dynamics and traditional integrated assessment quantitative modeling.

CONTENTS

LIST OF ACRONYMS USED IN THIS REPORT

ACLED	Armed Conflict Location and Event Data Project
AQAP	Al-Qaeda in the Arabian Peninsula
BBOE	Billion Barrels of Oil Equivalent
CSO	Central Statistics Office
CSP	Center for Systemic Peace
EIA	Energy Information Administration
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GIEWS	Global Information and Early Warning System
GPC	General People's Congress
HBS	Household Budget Survey
HDI	Human Development Index
IAM	Integrated Assessment Model
IDP	Internally Displaced Person
IFs	International Futures
IMF	International Monetary Fund
IPC	Integrated Phase Classification
ISIL	Islamic State in Iraq and the Levant
JMP	Joint Meeting Parties
MER	Market Exchange Rates
MoPIC	Ministry of Planning and International Cooperation
OHCHR	Office of the United Nations High Commissioner for Human Rights
PAM	Partitioning Around Methods
PITF	Political Instability Task Force
PPP	Purchasing Power Parity
SAM	Severe Acute Malnutrition
SDG	Sustainable Development Goal
SNA	System of National Accounts
STC	Southern Transitional Council
UAE	United Arab Emirates
UCDP	Uppsala Conflict Data Program
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations International Children's Emergency Fund
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNSD	United Nations Statistics Division
USD	United States Dollars
WDI	World Development Indicators
WEO	World Economic Outlook
WHO	World Health Organization
YER	Yemeni Rial



INTRODUCTION

The current conflict in Yemen is one of the greatest preventable disasters facing humanity. As such, many organizations have measured the impact of conflict on human suffering to better understand the severity of conflict. However, while the armed conflict has appropriately been the focus of much attention, its developmental impacts have not been studied across multiple pathways. In addition, no study explores the impact of conflict in Yemen on the Sustainable Development Goals (SDGs).

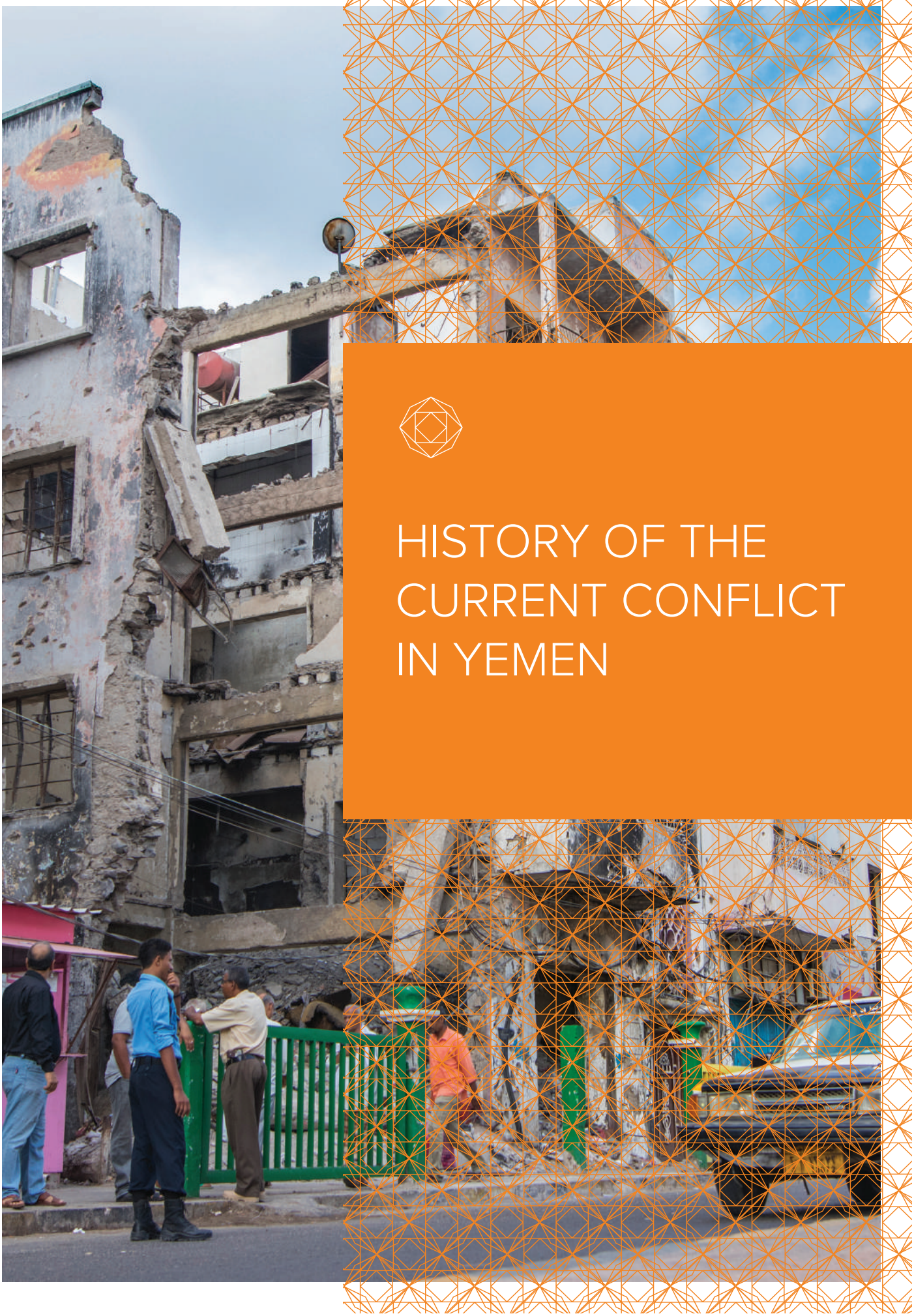
Conflict has been occurring in Yemen for decades. The current armed conflict escalated significantly in 2015 with clashes between the Houthi rebels and the Government of Yemen. It has embroiled a complex web of parties in addition, including southern separatists, terrorist organizations, informal militias and local tribal groups. Civil wars with many parties, such as this one, often take longer to resolve and complicate negotiations which results in extended periods of fighting.[1]

As the conflict continues, however, its costs—both direct and indirect—have become immense. A preliminary assessment estimated the 2015 physical and economic damage to be over US $15 billion.[2] From 2016–2018, over 63,000 combatants and civilians were killed due to direct violence.[3] If 2019 deaths continue at their current rate, over 22,000 more will die before the year's end. In December 2018, two million Yemenis were internally displaced, 89 per cent of whom have been displaced for more than a year.[4] More than 2,500 schools in 20 governorates have been damaged or occupied by internally displaced people (IDPs) or armed groups.[5] Significant damage has been done to food production and distribution systems,[6] while blockades, sieges and the destruction of crucial water infrastructure has weaponized water.[7]

Perhaps the greatest tragedies of the conflict have been the scale of suffering from hunger, poverty and sickness. Over half of the population is in Integrated Phase Classification (IPC) "Phase 3"—the crisis phase of the Famine Early Warning Systems Network.[8] Malnutrition has grown from an already high level and has resulted in 45 per cent of deaths of children under the age of five.[9] An estimated 3.3 million children in the country are malnourished, with one million suffering from moderate acute malnutrition and over 400,000 from severe acute malnutrition (SAM).[10] Between April 2015–October 2018, *Save the Children* estimates SAM caused the death of over 84,000 children.[11] And poor water and sanitation conditions have contributed to the largest cholera outbreak in epidemiologically recorded history[12] with more than 1.3 million suspected cases and over 2,600 associated deaths since the April 2017 outbreak.[13]

These estimates come from an assortment of organizations attempting to calculate the impact of armed conflict on aspects of development in Yemen and serve as the backbone of the analysis in this report. We build upon these studies by: (a) conceptualizing an impact model of armed conflict on development, building upon academic literature; (b) calibrating a quantitative model to simulate various conflict and no-conflict scenarios; and, (c) using clustering techniques to better contextualize how armed conflict in Yemen relates to other conflicts since the end of the Cold War.

The remainder of the report presents Yemen's history of conflict followed by a literature review assessing previous research on the impacts of armed conflict on development. Our modeling methodology is also outlined, which draws upon the International Futures (IFs) tool to better contextualize the impact of the conflict on development. And, finally, we present results that explore: (a) Yemeni development in the absence of conflict; (b) how conflict has impacted SDG achievement; and, (c) the impact of conflict on development if it ended in 2019, 2022 and 2030.



HISTORY OF THE CURRENT CONFLICT IN YEMEN

The conflict in Yemen has been described in various ways including as a proxy-war between Iran and Saudi Arabia, a broader Shia-Sunni conflict, and a bilateral struggle between the Houthi rebels and the Government of Yemen. But the reality is much more complex and "more closely resembles a region of mini-states at varying degrees of war with one another—beset by a complex range of internal politics and conflicts—than a single state engaged in a binary conflict."[14]

The Republic of Yemen was established in May of 1990 with the reunification of North Yemen (the Yemen Arab Republic) and South Yemen (the People's Democratic Republic of Yemen). Though formally a multi-party democracy, its first 20 years were led by President Ali Abdullah al-Saleh, head of the *General People's Congress* (GPC) and president of the North Yemen for 12 years before reunification. The *Joint Meeting Parties* (JMP) formed as an unlikely opposition coalition of six parties, including *Islah*, an Islamist/tribal party, and the *Yemeni Socialist Party,* formerly the ruling party of South Yemen.

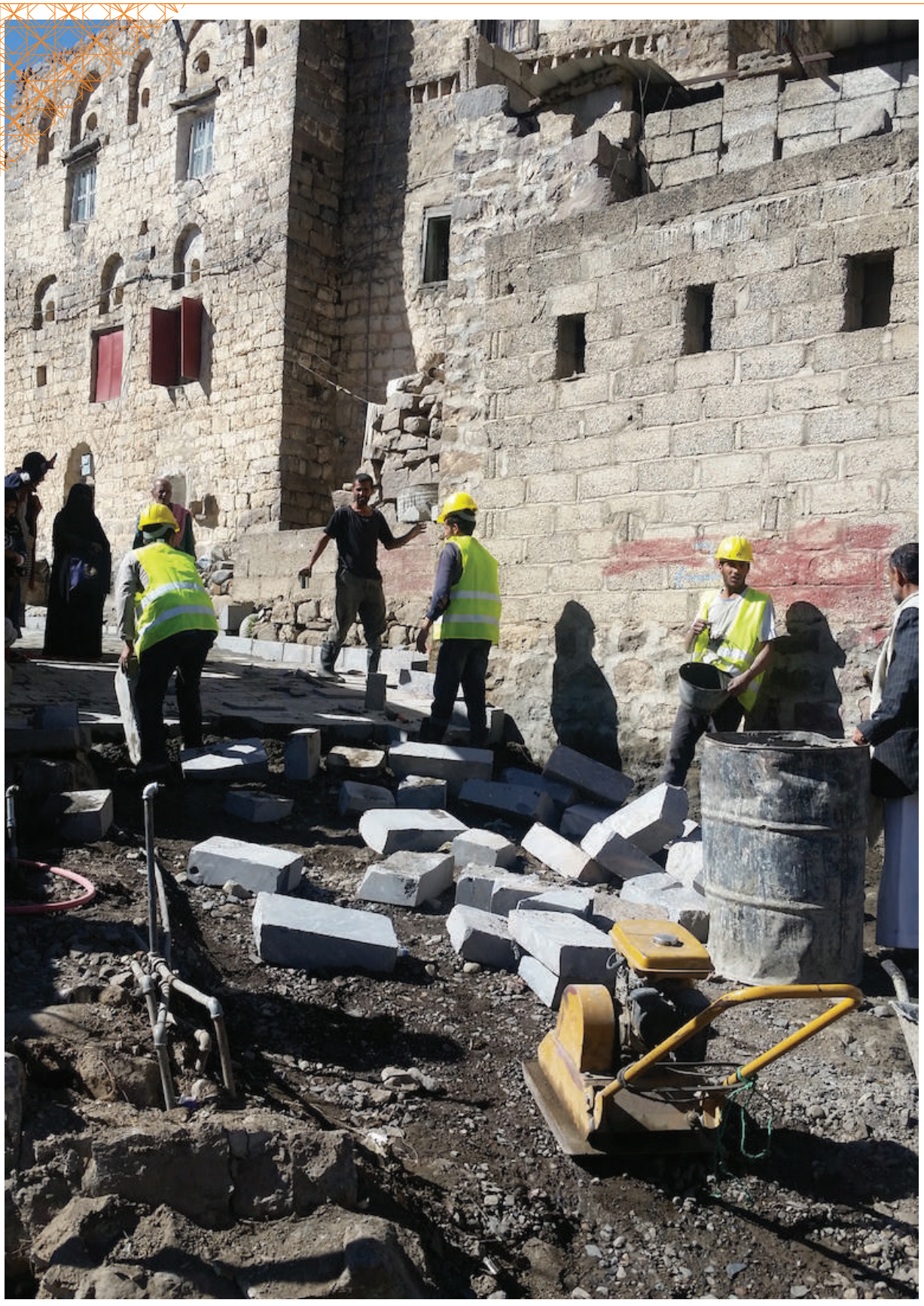
Separatist sentiment in the south has existed since reunification, which left many southerners feeling marginalized, and left out of Yemen's economic and political life. In 1994, tensions between some of the political parties in southern and northern Yemen culminated in a brief civil war which was quickly won by the north. This resulted in the exile of separatist leaders, forced the retirement of military officers and redistributed southern properties, including land.[15] Some of the retired officers began leading peaceful protests in the 2000s and, in 2007, created the separatist *Southern Movement* (also known as al-Hirak).[16]

In the northern governorate of Sa'dah, members of the *Zaydi Believing Youth* movement were also challenging Saleh's rule. The Zaydis ruled North Yemen for decades before being ousted in the 1962 revolution. The *Believing Youth* movement arose protesting the region's underdevelopment as well as Yemen's cooperation with the United States during the invasion of Iraq in 2003.

In 2004, President Saleh sent government forces to arrest the movement's leader, Hussain al-Houthi, setting off a series of clashes in Sa'dah.[17] Al-Houthi was slain in 2004 but taking his name—and under the leadership of his brother—the Houthis continued to battle Yemen's government off and on for six more years.[18]

In the last of these incidents, President Saleh set out to crush the rebellion with an "iron fist,"[19] and used tactics that caused civilian collateral damage. A ceasefire was reached between the Houthis and the government in 2010. However, the underlying grievances of the conflict were not addressed.

Al-Qaeda in the Arabian Peninsula (AQAP)—the Yemen branch of the militant Islamist organization al-Qaeda—formed in the 1990s. Through the 1990s and 2000s, it focused on Western targets—most notably the attack on the USS Cole in the Aden harbor in 2000, killing 17. However, AQAP was not initially a concern to most Yemenis and did not pose the same existential threat



to the government as the Southern Movement and the Houthis.

The 2011 Arab Spring provided the opportunity for many of these groups and grievances to coalesce. In Sana'a, demonstrations led by students and activists grew as leaders stepped down in Tunisia and Egypt. Protests spread throughout Yemen with JMP, Houthis and Southern Movement support. The movement hit a turning point on 18 March when government forces opened fire on demonstrators, killing dozens. There were mass resignations among the ruling party, including some 20 Members of Parliament and General Ali Mohsen al-Ahmar. The latter was often described as the "second most powerful man in the country"[20] who then used his influence to protect protesters. After months, President Saleh agreed to a deal designed with the Gulf Cooperation Council (GCC) that transferred rule to Vice President Abed Rabbo Mansour Hadi with power shared between the GPC and JMP political parties.

As part of the agreement, the National Dialogue Conference was designed to involve the protesting forces in drafting a new social contract; this process lasted nearly a year. Despite ongoing negotiations, Yemenis faced food insecurity, electricity outages and continued threat of violence.[21]

In 2012, and no longer in power, Saleh joined forces with the Houthis where he contributed funding and elite military units. Today's civil war was set off when the Houthis, with Saleh's support, took control of Sana'a in the fall of 2014 and then seized the presidential palace the following January. Hadi resigned, fled to Aden, and then reasserted his power. In March 2015 Saudi Arabia—in support of President Hadi and believing the Houthis to be closely affiliated with Iran—began leading airstrikes against Houthi targets.

Throughout the conflict, all sides have contributed to the devastation experienced by civilians. Parties to the conflict have attacked critical water infrastructure and systems of food production.[22] Food imports have not recovered from a general blockade or a port closure put in place in 2017,[23] and humanitarian groups and aid shipments have been blocked from reaching populations in need.[24] At the same time, a wartime economy has developed as traditional systems have collapsed. And while many Yemenis suffer, a few profit from taxing goods at checkpoints and an underground economy.[25]

The United Nations (UN) has been working with the parties to achieve a peaceful resolution to the conflict. In December 2018, the UN brokered a peace deal between the Houthis and the government in Sweden. Known as the *Stockholm Agreement,* it involved a prisoner exchange and agreement to withdraw from the Red Sea trade corridor—including the port city of Hodeida—critical for the import of food and humanitarian assistance. But disagreements have delayed implementation of the deal and hostilities have continued throughout the country.

WHAT ARE THE KNOWN IMPACTS OF ARMED CONFLICT ON DEVELOPMENT?

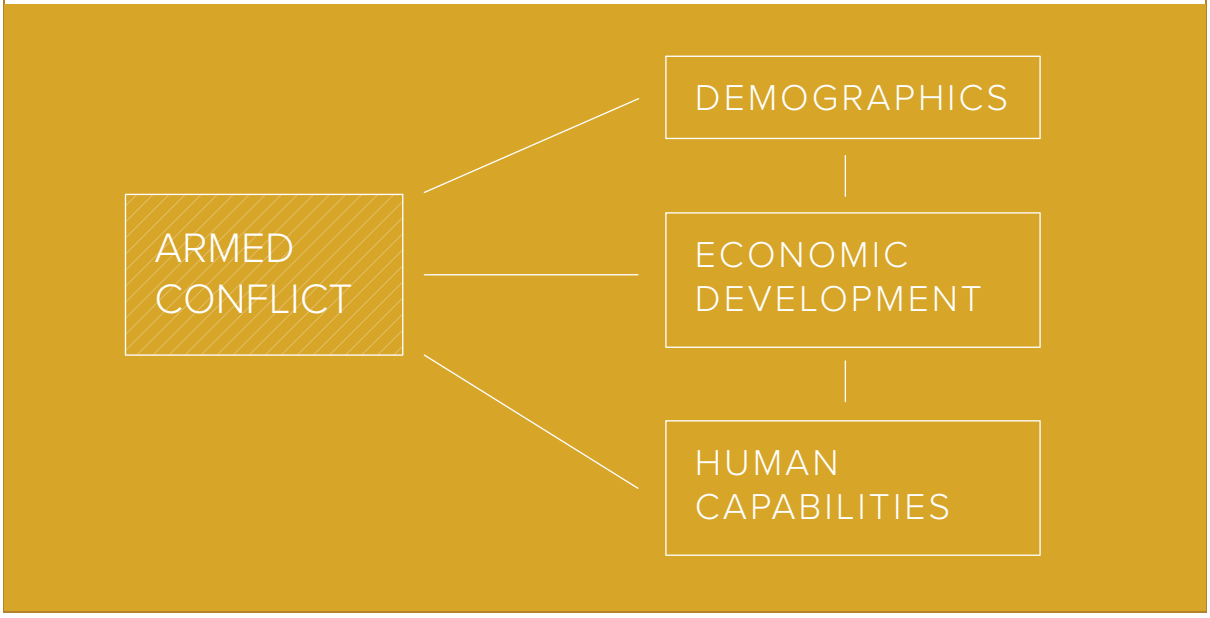
Armed conflict damages societies and development in obvious ways such as killing combatants and civilians and damaging infrastructure. But it also impacts development indirectly, potentially leaving lasting damage to human and social development and potentially outweighing direct impacts. For example, economic production grinds to a halt and agricultural land is abandoned. Children stop attending school. Food prices spike, and poor families struggle to feed their children. Displaced populations live in overcrowded and unsanitary conditions which become rife for disease.

To assess the direct and indirect impacts of conflict on development, the study focuses on three areas: demographics, economic development and human capabilities (Figure 2). Within these areas, we represent the effects of conflict on agricultural production, education, emigration, infrastructure, investment, morbidity, mortality, productivity and trade. We explore the effect of conflict on each of these areas directly and indirectly, and how those impacts in turn dynamically feed into broad future impact of human development.

The analysis in this report is focused on the macro-level impacts of armed conflict and development. Previous studies examined the effects of conflict on specific dimensions of development with most focusing upon the impact on Gross Domestic Product (GDP) indicators[26] while others focused on indicators of health[27] and human development.[28] The sections below provide a literature review of the impact of conflict on demographics, economic development and human capabilities along with a description of how this is unfolding in Yemen.

An alternative approach to analyzing these issues could focus on different aspects of the conflict and its relationship with development including: (a) the drivers of conflict; (b) conflict process; and/or, (c) reconstruction. The report does not, however, focus upon these areas, although they are exceedingly important. The report also does not try to predict whether the conflict will escalate, how the conflict will unfold, or estimate the level of resources required for reconstruction.

FIGURE 2 | *Conceptual framework used in this analysis.*



Conflict & Demography

MORTALITY

War directly affects mortality through deaths of combatants and civilians, as well indirectly by killing people through destroyed health infrastructure, agricultural systems and living conditions. Together, direct and indirect mortality make up "excess mortality"—the number of people killed by conflict who would otherwise be alive if the conflict had not taken place. Early in a conflict, direct violent deaths make up the bulk of excess mortality.[29]

Direct violent deaths are concentrated around adult men, who are most of the fighting forces.[30] These deaths can have a long-term impact on development as a shortage of working-age men in a population—a phenomena known as 'missing males'—leaves a demographic scar long after conflict ends.[31]

But typically as a conflict persists, indirect mortality surpasses direct mortality due to the breakdown of the health system, widespread hunger and degraded living conditions.[32] This is especially the case in least-developed countries, where baseline levels and health systems are already poor.[33] Indirect deaths are often concentrated among the most vulnerable—often women and children.[34] Some conflicts may even lead to more overall excess mortality among women than men.[35]

In Yemen, the Armed Conflict Location and Event Data Project (ACLED) recorded 63,138 combat-related deaths to combatants and civilians from 2016 to the end of 2018.[36] And the war appears to have caused even more indirect deaths. Save the Children has estimated that roughly 85,000 children have died from starvation since the beginning of the war.[37] And the under-five mortality increased from 53 deaths per 1,000 live births in 2013 to 56.8 in 2016.[38]

FERTILITY

Compared to mortality and migration, conflict's effect on fertility is less straightforward. It may act to lower fertility—as other economic shocks often do. Many conflicts have shown a temporary reduction in fertility during conflict years followed by a baby boom once fighting ends or eases.[39] However, persistent conflict can also increase fertility and the demand for children due to eroded social security, increased infant mortality, reduced knowledge of—and access to—reproductive health services, and lowered-levels of female education.[40] Households may also try to replace children lost to violence.[41] Conversely, some conflict situations may not impact fertility at all.[42]

The magnitude of impact of conflict on fertility in Yemen, though, according to one household survey, a greater portion of households reported pregnant or lactating women in 2016 (44 per cent) than before the crisis (23.4 per cent).[43]

MIGRATION

Violence is the largest driver of forced migration,[44] creating refugees who leave the country and Internally Displaced Persons (IDPs). The volume and destination of forced migration depend on many factors including conflict type and the characteristics of neighboring countries.[45]

Many conflicts create more refugees than IDPs[46] and civil wars with foreign interventions are more likely to drive mass-exodus migrations out of the country.[47] This is the case in Syria where war has created nearly as many registered refugees (5.6 million)[48]—not counting those not officially registered—as IDPs (6.2 million).[49] However, in Yemen, the displacement has been overwhelmingly internal.

As of October 2017, approximately 190,000 Yemenis sought refuge in neighboring countries[50]; however, over two-thirds are originally from elsewhere. Roughly 130,000 were migrants returning home as Yemen has

long been a country of asylum and transit for refugees and migrants from the Horn of Africa. [5152] Of the 60,000 refugees of Yemeni origin, half fled to Saudi Arabia, a third to Djibouti, and others to Oman and Somalia.[53]Roughly 130,000 of the refugees from Yemen are made up of migrants returning home, mostly to Africa.[54] At the same time, others continue to immigrate to Yemen despite the war. Over 50,000 people migrated from the Horn of Africa to Yemen in the first half of 2018, most of whom are Somali or Ethiopian and intend to continue to other Gulf countries.[55]

But the conflict in Yemen has created far more IDPs than refugees. The Office of the United Nations High Commissioner for Refugees (UNHCR) reported two million IDPs in Yemen in December 2018—89 per cent of whom had been displaced for over one year. One million former IDPs were able to return to their homes.[56] Most IDP returnees had been locally displaced during periods of large-scale and escalating conflict and returned home after that abated. Still, few returnees have achieved a durable solution and a quarter were not able to return to their original place of residence.[57]

The differences in displacement patterns in Syria and Yemen appears to be an issue of geography and policy. Syria shares borders with Jordan, Lebanon and Turkey. Turkey, for example, hosted millions after implementing an "open door policy" for Syrian refugees in the conflict's early years[58]and many have more recently sought to apply for asylum in Europe.[59] Displaced Yemenis simply do not have as many options to leave the country.

Yemen shares land borders with only Saudi Arabia and Oman. Some have fled across the Red Sea and Gulf of Aden to the Horn of Africa, but conditions are often poor in those countries. Saudi Arabia is a primary destination of Yemeni refugees, but has reportedly been expelling migrants from Yemen.[60] And Oman lies on the eastern border of Yemen, across a desert and far from most of the population.

Conflict & Economic Development

GROWTH, TRADE AND, INVESTMENT

Conflict generally reduces economic production due to the destruction of productive assets, diversion of resources and damage to human capital. Numerous conflict-related studies show a dampening effect on economic growth[61] with a few noting a specific reduction in productivity.[62] These include:

- Collier calculated that per capita growth during civil war is 2.2 percentage points lower than during peace.[63]
- Stewart, Huang, and Wang found the average annual growth rate for civil war countries to be -3.3 per cent.[64]
- Mueller finds that a four-year civil war reduces output from 7 to 22 per cent, and the more intense the conflict, the greater the damage to growth.[65]
- Gates et al. showed that a conflict with 2,500 deaths over five years reduces GDP per capita by 15 per cent.[66]

War often disrupts patterns of international trade and economic integration. Interstate conflict generally lowers trade[67]—both among and between hostile and neutral parties[68]—although some studies have failed to find a significant effect.[69] Civil conflict can also reduce trade through increased political risk, higher transportation

and communication costs, and by shrinking a country's consumptive and productive capacity.[70]

Conflict is also likely to take a toll on investment. Political risk and insecurity can result in capital flight and lower levels of domestic investment.[71] It may also lower levels of foreign direct investment (FDI) as it increases the risk of investing in a country.[72] Although primary sector FDI (made up largely of natural resources) may be less affected than FDI in other sectors.[73]

Prior to the conflict, Yemen was not deeply integrated within the global economy, with natural resources making up the bulk of trade and foreign investment. Oil and natural gas made up 90 per cent of Yemen's exports and 88 per cent of FDI between 2005 and 2010.[74] Capital flight has been a problem for decades. Between 1990 and 2008, US $2.70 left the country illicitly for every US $1 received in aid.[75]

War has brought the country's economy to a halt. Yemen's GDP has contracted every year since the conflict began, shrinking nearly 28 per cent in 2015, 9.8 per cent in 2016, and -5.9 per cent in 2017.[76] Over a third of businesses have closed and more than half of those still open have scaled down.[77] Oil production has come to a standstill and while gas extraction continues, it is primarily for the domestic market.

Oil and gas production overall has fallen 90 per cent since 2014, leaving the country with limited foreign exchange.[78] Imports have been halved since 2014, and with the Central Bank of Yemen largely inoperable, go primarily through unofficial channels.[79]

INFRASTRUCTURE

The destruction of infrastructure is one of the most visible effects of violent conflict. Strategically, parties may directly target transportation and telecommunications infrastructure[80] or environmental infrastructure (water, energy, waste, and sanitation).[81] However, beyond the direct costs, infrastructure damage causes problems with economic and human development and is likely to raise the cost of production and deter investment.[82] Furthermore, damaged transportation infrastructure delays the movement of not just goods, but critical food aid. And the targeting and weaponization of water and sanitation infrastructure is especially concerning as they are directly associated with communicable diseases and food production.[83]

Even prior to the conflict, poor transport and logistics infrastructure was a limiting factor in the competitiveness of Yemeni firms. For instance, unreliable electricity access made firms dependent on costly generators and, by extension, fuel. In 2013 businesses even in major cities dealt with average power outages of four hours a day.[84] These existing challenges are made much worse by a war that has involved the direct targeting of infrastructure, especially that supporting water and sanitation.[85]

A 2016 damage and needs assessment estimated the cost of damage to overall physical infrastructure (including housing) to be between US $4–US $5 billion. This includes: (a) US $88–US $108 million in damage to transportation; (b) US $125–US $153 million to energy; and, (c) US $79–US $97 million to water, sanitation and hygiene.[86] Over half of respondents to a 2018 survey said that local water and electric infrastructure had been damaged, over 40 per cent listed health and education infrastructure and over 30 per cent mentioned roads were damaged.[87]

AGRICULTURAL PRODUCTION

Conflict reduces agricultural output[88] and efficiency.[89] Widespread land abandonment may result from farmers being displaced, killed or unable to support production.[90] During periods of heightened insecurity, many households shift away from more profitable crops requiring higher investment to subsistence farming of lower-risk crops[91] and cut back on investments that would increase productive capacity.[92] Labor shortages result from workers being displaced, injured or killed,[93] and key inputs such as seeds or fertilizer may become pricier and/or more difficult to obtain.[94]

In Yemen, agricultural production has reduced significantly. Land has been abandoned as farmers and agricultural workers are displaced, crops and fields have been directly attacked, and fuel shortages have increased the cost of production and transportation.[95]

Water scarcity is the most important factor limiting agricultural production and fuel shortages have made irrigation costlier. In 2016, the area cultivated decreased by 38 per cent, on average.[96] In the heavily agricultural Tihama region, all groundwater-related agriculture was suspended, cultivated areas fell to 39 per cent of pre-war levels and yields were reduced to 42 per cent pre-war levels.[97]

Conflict & Human Capabilities

POVERTY

By reducing economic growth and destroying the mechanisms of redistribution, conflict leads to increased levels of poverty. Collier calculated that a seven-year conflict reduces income by 15 per cent and raises poverty by 30 per cent.[98] At the household-level, conflict can lead to the loss of physical and human capital. Houses, land, livestock and other productive assets may be destroyed or stolen.[99] The death, injury, disability and trauma caused to household members reduces income[100] while food prices increase, leaving many households struggling or unable to buy staple items.[101] These losses—along with conflict-induced effects on markets and human capital—can leave countries in a state of chronic and structural poverty.

In Yemen, the current conflict has exacerbated already high levels of poverty. By the fall of 2015, 45 per cent of Yemenis surveyed said they had lost their main source of income due to the conflict.[102] Public employees have not received full and regular salaries since the fall of 2016, ultimately reducing incomes and hurting sectors like health and education.[103] In 2017, 48 per cent of the population lived on less than US $1.90 a day (up from 30 per cent in 2015) and 78.5 per cent lived on less than US $3.20 (up from 65.6 per cent in 2015).[104]

MORBIDITY

In addition to the death and injury of combatants and civilians, war destroys crucial health infrastructure and degrades living conditions. This results in a significant loss of healthy life, with the greatest losses experienced by children.[105] Conflict destroys healthcare facilities, reduces the pool of health workers, diverts health spending and reduces access to health services.[106] Critical intervention and vaccination programmes may be disrupted, leading to disease resurgence.[107] Water and sanitation infrastructure—often already inadequate—may be further degraded.[108] And many displaced populations are forced to live in overcrowded conditions with low vaccination coverage, encouraging the spread of infectious diseases.[109]

Conflict is also closely linked to hunger and food insecurity.[110] Most famines today are the result of armed conflict and often made worse by natural disasters.[111] Parties to the conflict may use food as a weapon, cutting off food supplies, destroying systems of food production and distribution, and stealing food aid. Agricultural production falls, which both limits the availability of food and cuts off many rural houses from their livelihoods. And with higher levels of poverty, many families cannot afford the food they need, especially at inflated prices.

In Yemen, war has devastated an already weak health system, characterized by low levels of access and financial protection. Health services have historically been provided by fixed facilities which are unable to

reach the entire population. As a result, half of the population (two-thirds in rural areas) lacked access to healthcare services even prior to the conflict.[112]

At least 278 health facilities have been damaged or destroyed and under half of the health facilities in the country are fully functional.[113] Those that are in operation struggle with shortages of essential medicines, supplies and healthcare workers, as well as a lack of resources, safe water, fuel and power.[114]

Food prices were already climbing prior to 2015 and widespread hunger has left much of Yemen's population especially vulnerable. Between 2009–2011, the food inflation rate was greater than 20 per cent and by 2012, nine out of 10 households surveyed said that they were having a harder time securing food due to rising food prices.[115] But the conflict has brought the country to the brink of famine.

Systems of food production and distribution have been targeted for destruction,[116] and food imports have not recovered from a port closure in late 2017.[117] In 2017, food production fell 20–30 per cent compared to 2016,[118] and by October of 2018 retail food prices were 73–178 per cent higher than pre-crisis levels.[119] As a result, over half of the population is in Integrated Phase Classification (IPC) Phase 3—the "crisis" phase of the Famine Early Warning Systems Network.[120] Malnutrition has shot up from an already high-level and has caused 45 per cent of deaths to children under the age of five.[121] An estimated 3.3 million children in the country are malnourished, with one million suffering from moderate acute malnutrition and over 400,000 from SAM—two of the drivers of long-term developmental stunting.[122]

Finally, poor living conditions have facilitated the outbreak and rapid spread of disease. Water and sanitation conditions have been degraded by attacks on critical water infrastructure and overcrowding of displaced populations.[123] Over 19 million people lack adequate sanitation or safe water.[124] These conditions have led to the largest cholera outbreak in epidemiologically recorded history,[125] with over 1.3 million suspected cases and over 2,600 associated deaths since the April 2017 outbreak.[126] The conflict has also been associated with outbreaks of diphtheria[127] and measles.[128]

EDUCATION

Conflict impacts education by destroying infrastructure, reducing expenditures for schools and preventing children from attending classes. However, the broad evidence on the effect of conflict on a population's education is mixed, with some studies showing little-to-no impact.[129] It is possible that localized conflict can negatively impact education systems in one area but remain unaffected elsewhere.[130] When this happens, the harm to education experienced by one set of children is obscured by an overall national trend of improving educational attainment.[131] At the individual and community-level, exposure to violent conflict is still likely to have a negative impact.[132]

Conflict has been shown to reduce educational spending through the contraction of education services and the diversion of funds away from education and toward military and defense purposes.[133] And war often leads to the destruction and closure of schools, making it difficult or impossible for children to attend. Often displaced children may not attend school due to a lack of documentation, needing to work or a lack of education services.[134] Children may also stop attending school due to being abducted into soldiering,[135] to work[136] or simply because leaving the house is dangerous.[137] Exposure to war and violence is also likely to take a toll on children who remain enrolled because of stress and psychological trauma.[138]

Prior to the conflict, Yemen was making progress in education. Primary gross enrollment increased from 73 per cent in 1999 to 101 per cent in 2013, while girls' enrollment grew from 52 to 92 per cent in the same period.[139] But the conflict has set the country back significantly. An estimated 2,500 schools are out of use due to being destroyed, closed or occupied by IDPs or armed forces, leading to a 20 per cent increase in children not enrolled since the beginning of the conflict.[140]

Conflict & Gender

The impact of conflict is gendered, especially among the adult population. Adult men suffer most violent deaths, while most of the displaced are women.[141] Degradation of the health system can severely damage women's reproductive health.[142] Widowhood leaves a household especially vulnerable to poverty.[143] And conflict is associated with higher rates of gender-based and sexual violence.[144]

Women and girls in Yemen were marginalized prior to the current conflict. In 2014, Yemen's Gender Inequality Index, a composite measure created by UNDP, was already the worst in the world.[145] The female labor force participation rate of 8 per cent was the lowest globally.[146] Women had 1.6 fewer years of education than men,[147] and the difference between women and men on the Human Development Index (HDI) disaggregated by gender—0.21 points—was the largest gap of any country in the world.[148]

The chaos and violence since 2015—and already entrenched gender inequality—have had severe impacts. The war has resulted in increased rates of gender-based violence and child marriage.[149] Women and children make up three-quarters of the displaced.[150] And one-fifth of households of IDPs and host communities are headed by girls younger than 18 years of age.[151]

One understanding of how the conflict affects women comes from qualitative fieldwork taking place in the country. In one such study by Heinze and Stevens, they conducted interviews and discussion sessions in Marib, Taizz and Lahj.[152] Participants discussed increases in gender-based violence, early marriage and women's mobility being restricted by heightened insecurity. Many women have taken on new roles and responsibilities, primarily due to the injury or the absence of men. And while these changes for some women have been empowering, for others they are an additional burden.

METHODOLOGY

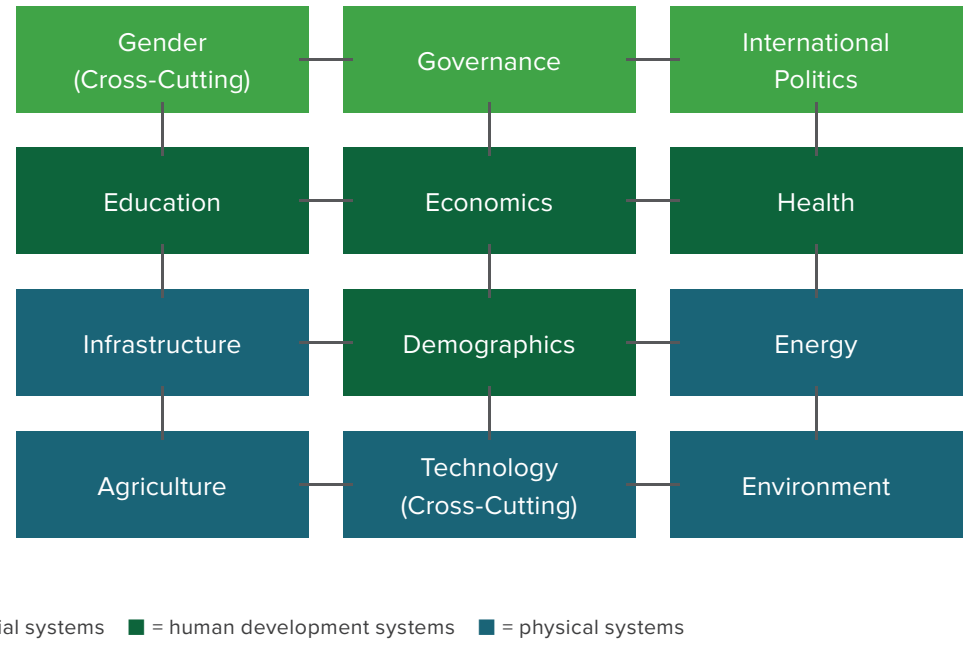
For this report we use the International Futures (IFs) tool, an open-source integrated assessment modeling platform originally created by Professor Barry B. Hughes. IFs are currently maintained and developed at the Frederick S. Pardee Center for International Futures at the Josef Korbel School of International Studies, University of Denver. IFs include the following inter-connected modules: agriculture, demographics, economics, education, energy, environment, gender, governance, health, infrastructure, international relations and technology (Figure 3). The IFs tool projects development patterns for hundreds of variables across these issue areas for 186 countries; it has been used widely for policy and academic publication and has been under development for 40 years. It is open-source and free to download and use.

The IFs tool is unique in the number of issue areas that it covers, an important attribute needed to broadly assess the impact of conflict on development. See *International Futures: Building and Using Global Models* by Barry Hughes for an overview of the tool.[153]

For Yemen, we calibrated IFs using data and estimates from 2015 to present. Many data series used in IFs come from standard international sources such as the Food and Agriculture Organization (FAO),[154] the United Nations International Children's Emergency Fund (UNICEF)[155] and the United Nations Conference on Trade and Development (UNCTAD).[156]

Because this report assesses the impact of an ongoing conflict, many data series were missing. Additional data were required for model simulation and were gathered from organizations estimating on-the-ground development in a war-zone. We used these data estimates to calibrate the IFs model platform for Yemen

FIGURE 3 | *Conceptual overview of the International Futures (IFs) system.*



to simulate the impact of conflict to present day. See Annex 1 for an assessment of data used to calibrate the model for this report.

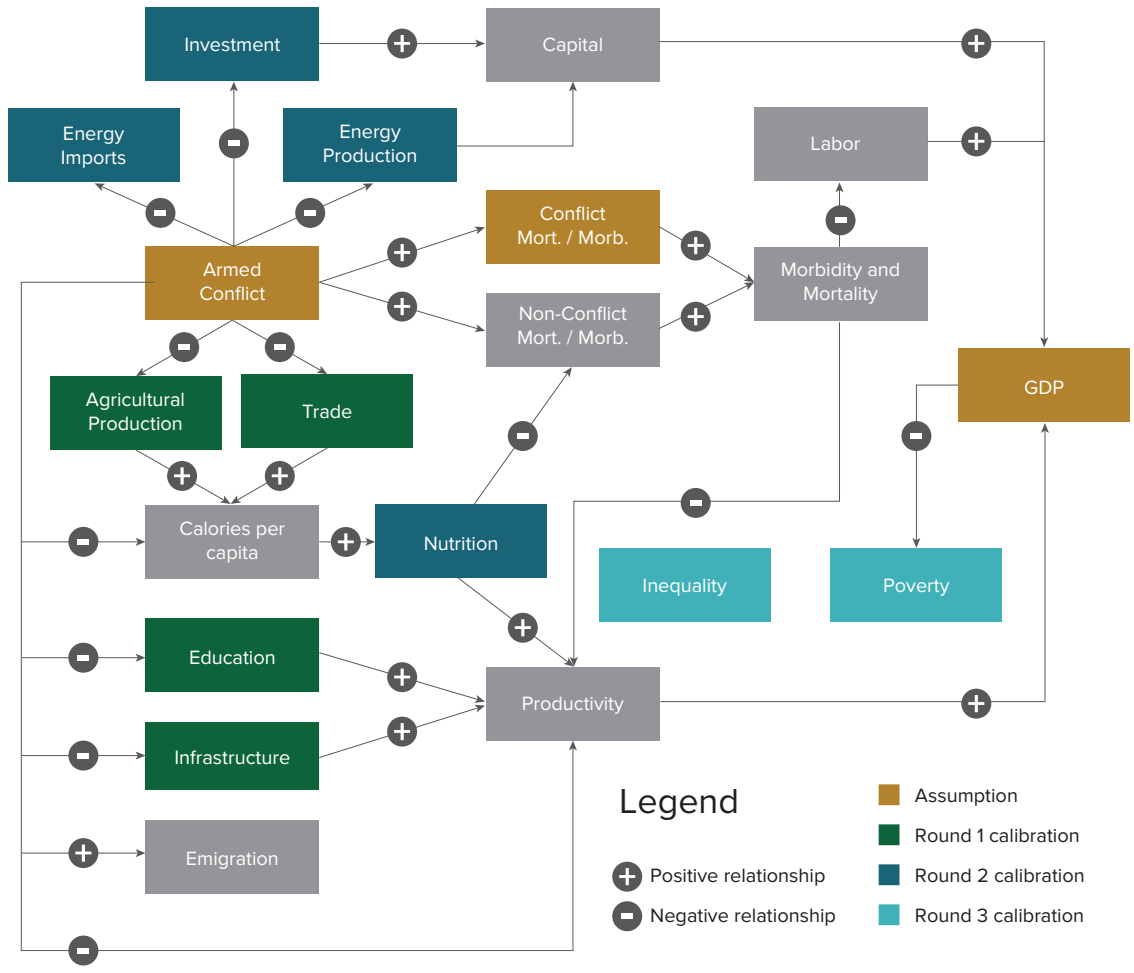
We calibrated the model in stages, starting with the variables measuring the largest and most direct impact of conflict, that we consider core assumptions: (a) direct conflict deaths; (b) the "magnitude" of conflict; and, (c) GDP growth rates. The model structure and calibration sequence are identified in Figure 4.

After adding these assumptions to IFs, we then explored their impact on other indicators beginning with the "Round 1" calibration set. The first round of calibration focused on agricultural production and trade, as well as basic access to education and infrastructure services. We compared our calculated variables with estimates made by others and adjusted the model. After we completed "Round 1" of calibration we then moved to subsequent rounds.

The result of this exercise is a model that reflects the impact of Yemen's conflict on development through early 2019 embedded within the IFs framework. In other words, the systems identified in Figure 4 were added to the broader conceptual framework identified in Figure 3.

Next, we constructed two types of alternative scenarios. First, we created a counterfactual *No Conflict* scenario that simulated a world in which conflict did not exist after 2014 in Yemen. This scenario is a benchmark that reflects a reasonable development trajectory that describes a more optimistic world than the conflict scenarios. It is a dynamic, non-linear scenario that considers trade-offs in the development process.

FIGURE 4 | *Conceptual model framework used within the International Futures modeling platform.*



There was debate about whether 2015 was the correct starting point for the *No Conflict* world as conflict in some form has been ongoing in Yemen since 2004. Government forces and the Houthis clashed intermittently from 2004–2010 and 2011 protests sparked crisis and violence amid existing insurgent movements. But the international intervention and escalation of fighting in 2015 caused a conflict categorically different from previous conflict years.

The second set of scenarios created for this work extended the conflict calibration through early 2019 and made assumptions about how conflict would persist through the end of 2019, 2022 and 2030. These four scenarios are described in Table 2.

The scenario assumptions were intended to be reasonable and show a reduction in conflict deaths from 2018–2019 (Figure 5). The core assumptions of these scenarios are outlined in Annex 2, showing a reduction in conflict deaths and improved GDP growth rates (asymptotically approaching zero by 2030). By 2030 we assume that conflict deaths are about half of conflict deaths in 2018 and GDP growth is near zero.

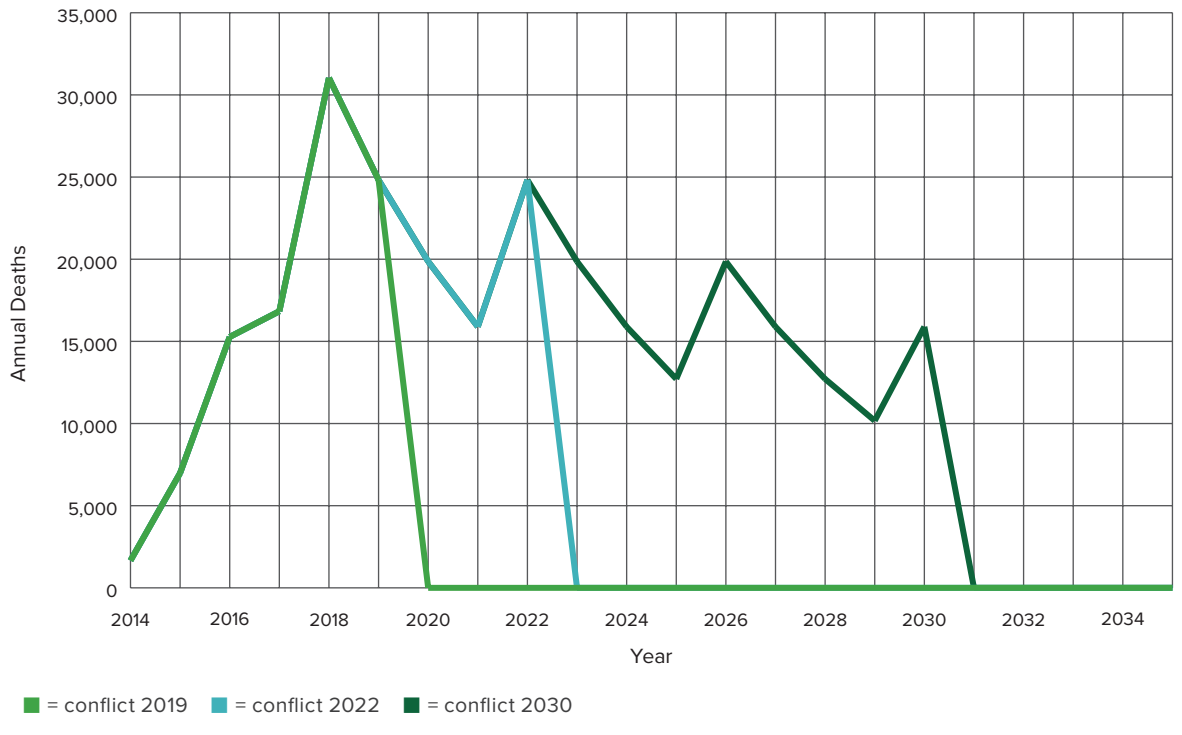
The final methodological step contextualized the impact of armed conflict on development in Yemen within the recent history of armed conflict. How does the conflict in Yemen compare to other conflicts since the end of the Cold War? To do that, we created five clusters of conflicts based on conflict severity and impact on development. In some countries, for example, the impact of conflict on macro-level development trends is muted (e.g. India, a large country with localized conflicts). In other countries, the developmental impacts are monumental (e.g. Rwanda).

The analysis conducted in this report involves many methodological contributions using various tools and techniques, but it also has limitations. First, because the dynamics of an unfolding conflict are difficult to predict, our future scenarios assume a reducing severity of conflict that then has dynamic impacts on development pathways. However, the future conflict could unfold in very different ways from our assumptions; it can be either more or less pernicious, or have different impacts on direct and indirect mortality depending on technology, external involvement or other factors.

TABLE 2 | *Scenario names and assumptions. See Annex 2 for a longer discussion of assumptions.*

Scenario Name	Description
No Conflict	A counterfactual scenario in which the Yemen conflict *did not* escalate in the beginning of 2015 and the associated developmental gains as a result of no conflict.
Conflict 2019	A scenario calibrated to the impact of conflict on development in Yemen through early 2019. It assumes that conflict deaths are the highest in 2018 and decline in 2019, but that conflict ends at the beginning of 2020. Conflict magnitude is scaled to reflect historical conflicts with similar characteristics.
Conflict 2022	A scenario calibrated to the impact of conflict on development through early 2019 with conflict concluding at the end of 2022. Conflict deaths in 2019 are lower than 2018 and continue to decrease between 2020–2022. GDP growth—although it remains negative—is higher through 2022. The conflict magnitude is scaled to reflect historical conflicts with similar characteristics.
Conflict 2030	A scenario calibrated to the impact of conflict on development through early 2019 with conflict concluding at the end of 2030. Conflict deaths in 2019 are lower than 2018 with the conflict mortality trending in a non-linear reduction (see Figure 5). The GDP growth rate nears zero percent by 2030. The conflict magnitude is scaled to reflect historical conflicts with similar characteristics.

FIGURE 5 | *Conflict deaths across three scenarios, history and model assumptions.*



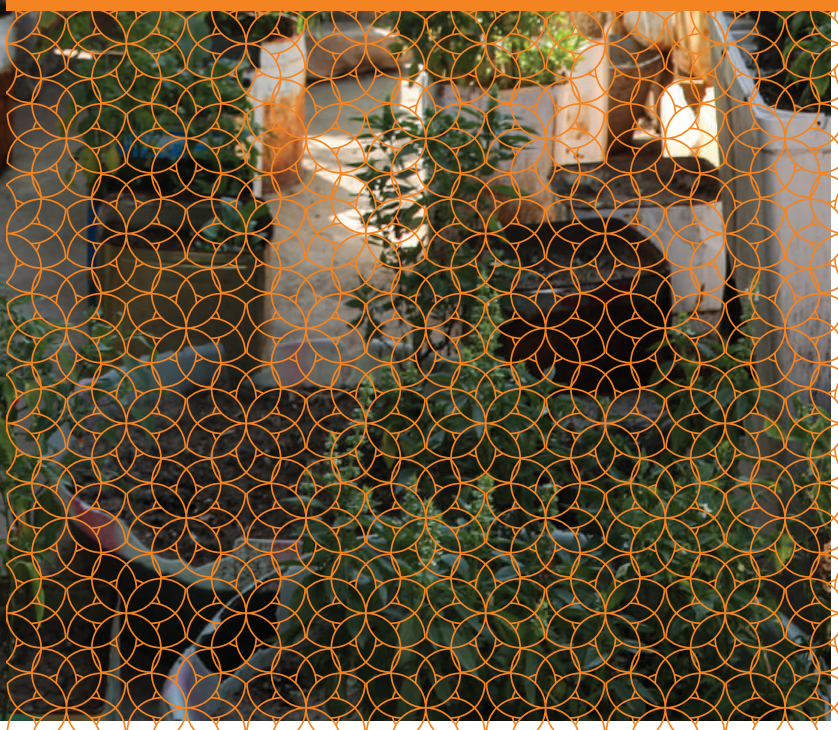
Our treatment of uncertainty and model complexity is a second type of limitation. Future projections must be consumed with caution as different projections may have more or less reliability depending on the issue area, quality of data and accuracy of conceptual models. For example, demographic projections are widely understood to be of high quality and reliable over long time horizons. Predicting the number of conflict fatalities in the next month or quarter is fraught with uncertainty.

Some simple models can treat uncertainty through longitudinal sensitivity analysis by estimating the error bands. This may be useful in helping consumers understand the likelihood of projected trends; however, it is difficult to apply in this modeling exercise. This is because we use a systems-dynamics approach that proceeds sequentially through multiple calculations and not a single econometric model that produces single error estimates.

To frame the sensitivity of our model results to changing assumptions, we created alternative “high” and “low” scenarios (not presented in this report). These reflect increased or decreased assumptions about mortality, magnitude and GDP growth. The impact of these scenarios on our developmental outcomes does not change our conclusions and provides justification for the robustness of the results.

The treatment of uncertainty within the study also relates to the complexity of models used in the analysis. In general, simple models are superior to more complex models if they can successfully and transparently convey the same findings using fewer assumptions; however, they can also miss emerging dynamics and structural changes. More complex and integrated tools—while more difficult to use and explain—also capture more interacting variables and may be able to better describe dynamic and emerging developmental trajectories.

ANALYSIS OF THE IMPACTS OF CONFLICT ON DEVELOPMENT IN YEMEN



We assess the developmental impacts of conflict in Yemen by first modeling development without conflict after 2014 and within the context of Agenda 2030 and Sustainable Development Goal (SDG) achievement. Here we find that Yemen was not poised to achieve any SDGs in the absence of conflict (of those analyzed in this modeling exercise), and that the onset of conflict set the country's Agenda 2030 progress back even further.

We then evaluate the future impact of conflict across three conflict termination dates: 2019, 2022 and 2030. We find that the conflict has a negative impact on the lives of the most vulnerable—with growing child and infant mortality representing the bulk of new conflict deaths. We conclude by positioning the impact of Yemen's conflict on development by exploring how the conflict clusters with alternative conflicts, beginning with the Cold War. We find that—even if the conflict ended in 2019—it would cluster with other extremely high-impact mass conflicts, leaving developmental scars for generations.

Evaluating the No Conflict Scenario

By 2014, Yemen's population had more than doubled since the country's reunification in 1990 with more than 26 million people. At the same time, the fertility rate fell from 8.5 births per woman in 1990 to just over four in 2014. With a median age of 19 and 41 per cent of the population younger than 15, Yemen was among the youngest countries in the Middle East and North Africa (MENA) region. A GDP[1] per capita of US $3,800 put Yemen at a similar level to Ghana in the same year, and in the upper half of the World Bank's lower-middle income group.[157] Yemen had the 46th largest proportional burden of extreme poverty in the world,[158] with half of the population living in poverty (defined as living on less than US $3.10 per day) and one-in-five people living in extreme poverty (less than US $1.90 per day). The average Yemeni could expect to live to around 65 years of age and had completed 4.2 years of education.

Children were in an especially fragile situation, even before the escalation of conflict. A child born in Yemen in 2014 was most likely delivered at home without skilled assistance or antenatal care.[159] Of every 1,000 children born, approximately 50 would die before reaching their fifth birthday—over 90 per cent within their first year of life. In addition, 40 per cent of children under five years of age were malnourished and 58 per cent of the population lacked access to piped water.

In Yemen in 2014, pneumonia and diarrhea were major causes of death in children under the age of five[160]—both of which are linked to poor nutrition and unsafe water and are easily preventable through adequate treatment. But roughly one-in-four children in Yemen under the age of five suffered from diarrhea without receiving treatment, and less than half with suspected pneumonia would be brought to a health facility, with just 17 per cent receiving antibiotics.[161] Moreover, a low vaccination rate increased the likelihood of disease outbreak.[162]

A Yemeni child born in 2014 entered a country struggling with food insecurity, a high burden of poverty and limited infrastructure. But in the absence of conflict, that child would grow up in a country that was steadily improving. By 2030 in the *No Conflict* scenario, 24 per cent of the population would live in poverty (half the level in 2014) and less than 7 per cent in extreme poverty. The average Yemeni would live to 69.5 years (five years longer than

1 Throughout this report, unless otherwise specified, GDP and all currency figures are measured in 2011 US dollars. There are two ways to measure GDP and/or per capita output. Market exchange rates (MER) measure the value of output in local currencies against prevailing market exchange rates for the 2011 US dollar. Purchasing power parity (PPP) is calculated for each country relative to its cost of living and inflation rates. It considers how much of one currency would have to be converted into that of another country to buy a comparable basket of goods and services in that country. GDP measurements in PPP tend to be higher, particularly for developing countries. Unless otherwise noted, GDP measurements from IFs are in MER and GDP per capita measurements from IFs are in PPP.

in 2014) and would have 1.6 additional years (an average of 5.8 total years) of education. GDP per capita would increase 56 per cent by 2030 to around US $5,900. Human development would progress as well, with HDI increasing 18 per cent to 0.61.

Critically, the outlook for children born in 2030 would be significantly improved in a world without conflict. The reduction in poverty would help to alleviate hunger, bringing child malnutrition under 25 per cent—or half-a-million children fewer than in 2014. There are 10.5 million Yemenis that would gain access to improved sanitation and 10.3 million to piped water relative to 2014, resulting in a reduction of morbidity and mortality burdens from communicable disease. Improvements to healthcare access and quality would lower the risk to both mother and child with the likelihood of a woman dying during childbirth and that of losing a child before their first birthday would be cut in half by 2030 compared with 2014.

The *No Conflict* scenario illustrates that in the absence of conflict, quality of life would have improved for many Yemenis and progress towards development would have become more resilient. Additionally, the window of opportunity for Yemen to benefit from international cooperation, innovation, investment and restructuring would have been much wider, increasing the likelihood of better-than-expected performance. This is particularly the case considering critical Agenda 2030 mandates such as the resolution to leave no country or person behind and to "reach the furthest behind first."[163] But while the elimination of conflict has definite positive impacts on development outcomes in Yemen, it does not solve all of Yemen's development problems. Our projections from this scenario indicate that a *No Conflict* Yemen would still be unlikely to achieve any SDG targets by 2030.

The Measured Impact of Conflict on the SDGs

The *No Conflict* scenario is a counterfactual, a depiction of what the development pathway of Yemen might have been without the sizable escalation of conflict in 2015. In reality, conditions in Yemen deteriorated sharply post-2014.

The war killed hundreds of thousands directly and indirectly and destroyed critical health and education infrastructure. By 2017, 48.2 per cent of the poverty lived in extreme poverty[164] and life expectancy declined by one year.[165] HDI fell nearly 10 per cent from 2014–2017, pushing Yemen to 2001 levels. Hunger became a widespread and deep-rooted issue—FAO reports that one-third of the total population is undernourished, while the IPC reports that over half of the population is currently faced with severe acute food insecurity.[166] FEWS NET has reported that food imports and distribution of food aid are a critical lifeline for much of the population. If these flows were to be disrupted it could lead to widespread famine conditions in the country.[167]

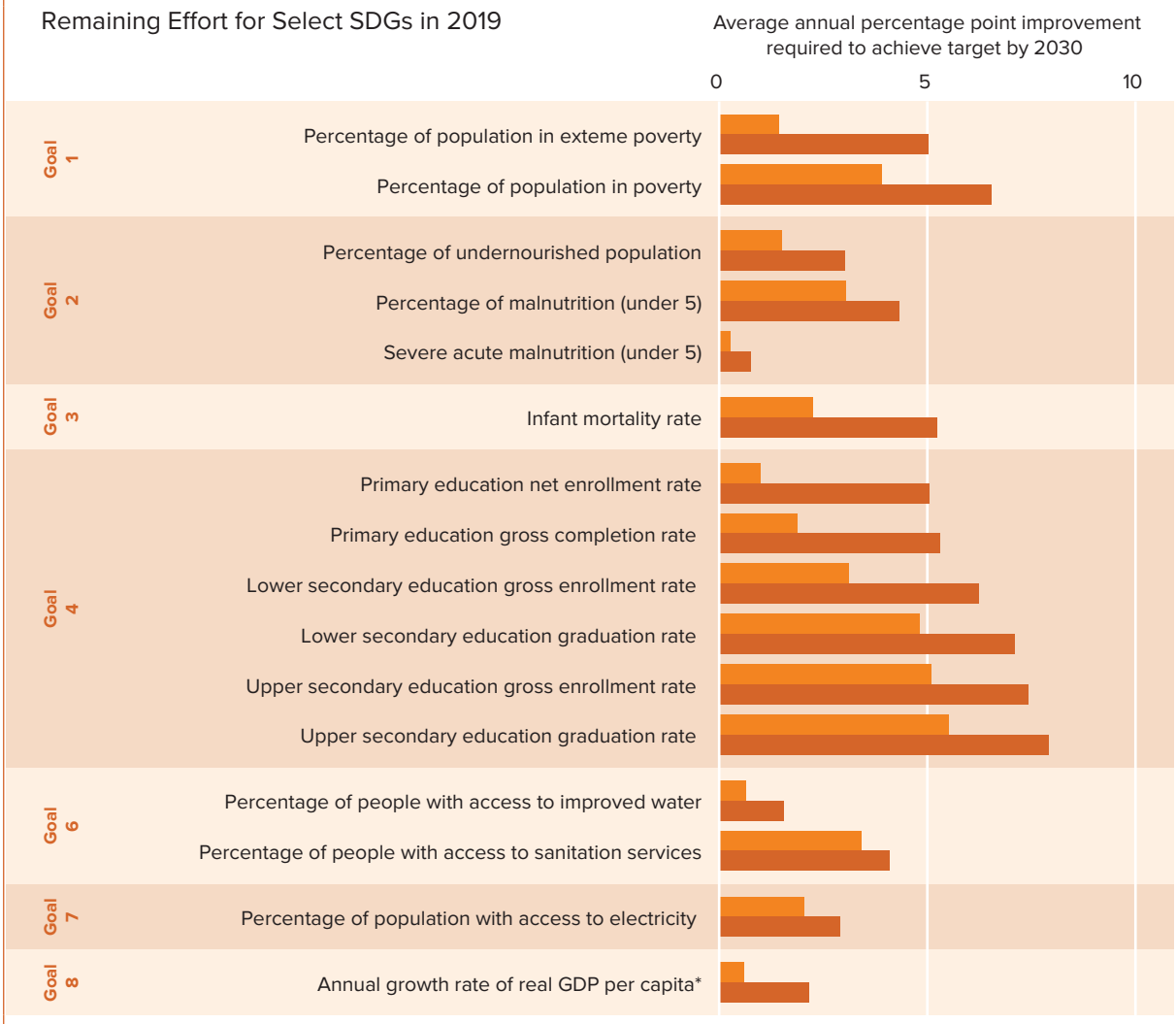
Children have been affected disproportionately with one-half of children under five undernourished, and nearly 400,000 children suffering from severe acute malnutrition.[168] While the last available survey estimates on child and infant mortality were gathered in 2012,[169] the results from the UN Inter-Agency Group for Child Mortality Estimation suggest that these figures could have been between 38–79 child deaths per 1,000 live births in 2017—or between 33,000–69,000 dead children. In 2017, this marks a mortality rate that is between 5.5–11.5 times higher for children under the age of five than those aged 5–14.[170]

The situation today has broad implications for Yemen's development path moving forward. After five years of conflict, progress towards the SDGs has been subject to considerable backsliding. While Yemen was not projected to meet any of the SDG targets even in the absence of conflict, Yemen today will face an enormous

uphill battle. Figure 6 illustrates both how far Yemen would be from achieving the SDGs under *No Conflict* conditions (bars colored light red) and how far away it is in 2019 (bars colored dark red), using the average annual percentage point change necessary to achieve a given SDG. Displayed is a select group of indicators across seven human development SDGs.

As an example of the effect of conflict on Yemen today, extreme poverty rates would need to be reduced by five percentage points every year from now until 2030 to meet the SDG targets. In a *No Conflict* Yemen, by comparison, extreme poverty would only need to be reduced by 1.4 percentage points each year to meet the SDG targets. If Yemen is to meet the targets for extreme poverty reduction, poverty rates must decline 3.5 times faster than they would have had to in the absence of conflict—a rate of reduction historically unseen. Under the *No Conflict* scenario, by comparison, the sustained rate needed to achieve the extreme poverty SDG target would have been just 0.2 percentage points higher than the global average for a given 11-year period.

FIGURE 6 | *Average annual percentage point change needed in given SDG indicator to achieve SDG targets by 2030.*



Where target is to "eliminate" hunger, poverty, etc. the threshold is interpreted here as below 3 per cent (below 2 per cent for water and sanitation goals). *Period necessary to sustain annual growth rate of real GDP per capita to achieve target is interpreted here as five years.

■ = no conflict (2019–2030) ■ = today's value (2019–2030)

The Future Impact of Conflict on Development in Yemen

We created three conflict scenarios that made assumptions about the future trajectory of direct deaths, conflict magnitude, and GDP growth rates. Those assumptions are outlined in Annex 2 and were described in the methodology section of this report. All other results presented here, including indirect deaths, are the result of modeled analysis of the impacts of conflict on development. Table 3 presents various developmental indicators in terms of their value by scenario, cumulative value across the time horizon to the end of conflict, and the comparison between the conflict scenario and the *No Conflict* world.

By comparing the conflict scenarios with the *No Conflict* scenario (Table 3, far right panel), we can estimate the war's total excess mortality based upon the count of people who would not have died (directly and indirectly from the conflict) if there had not been a war. If the war ends in 2019, it will have led to an additional 233,000 deaths. Of these, 102,000 are the direct result of combat violence.[2] If the conflict persists to 2030, that grows to 300,000 people.

Direct conflict deaths are a key assumption in this modeling effort (see Methodology). While the direct conflict violence mortality is large, indirect excess deaths are larger and grow much more rapidly. If conflict ended in 2019, indirect deaths would total 130,000. If the conflict persists for 11 more years to 2030, it will kill 1.5 million additional people from hunger and disease. For every one Yemeni who dies directly from conflict, five more die indirectly.

TABLE 3 | *Human development indicators in Yemen by conflict scenario.*

		Value			Cumulative value from 2014			Cumulative difference (relative to *No Conflict* from 2014)		
Scenario		2019	2022	2030	2019	2022	2030	2019	2022	2030
Direct Deaths	*million people*	0.03	0.03	0.02	0.1	0.17	0.3	0.1	0.17	0.3
Indirect Deaths	*million people*	0.22	0.26	0.42	1.19	1.93	4.66	0.13	0.32	1.48
GDP at MER	*billion US*	20.1	18.5	15.6	147	204	338	-89	-181	-657
Extreme Poverty*	*million people*	17.3	20.7	30.1	76.6	135	342	43.6	86.6	265
Malnourished Children	*million children*	2.1	2.6	4.4	11.2	18.5	47.4	1.6	4.4	22.7
Malnourished Population	*million people*	10.7	15.4	37.1	50.6	91.4	314	13.4	37.3	220
No Access to Electricity	*million people*	10	12.6	20.7	50.8	86	222	6.7	20.4	109
No Improved Sanitation	*million people*	14	16.9	25.6	73.2	121	295	5.4	16.6	92
No Safe Water	*million people*	20.9	24.8	32.5	107	177	411	7.2	25	121
Missing Students	*million children*	5.9	6.7	7.8	27.1	46.5	105	10.3	21.2	57.4

*Poverty line of US $1.90 a day used here.

2 Note again that direct conflict deaths are a model assumption.

TABLE 4 | *Results for select SDG indicators in 2014 and in 2030 for all scenarios.*

		2014	2030			
Goal	Indicator	No Conflict	No Conflict	Conflict to 2019	Conflict to 2022	Conflict to 2030
1	Percentage of population below US $1.90 (2011 US $ PPP) per day; Lognormal	18.8	6.6	33.0	43.2	77.6
	Percentage of population below US $3.10 (2011 US $ PPP) per day; Lognormal	47.3	24.4	60.2	69.6	87.9
	Government spending on essential services (education, health) in billion US $	2.3	5.6	1.6	1.1	0.5
2	Percentage of undernourished population	25.2	11.8	23.0	27.3	95.5
	Percentage of malnutrition (weight for height is less than -2 standard deviations below the mean) among children under five	42.1	24.6	38.0	45.5	79.5
	Severe Acute Malnutrition (weight for height is less than -3 standard deviations below the mean) among children under five	5.2	3.0	3.6	3.7	8.7
3	Infant mortality rate in deaths per thousand newborns	46.3	21.3	44.7	59.4	136.6
4	Primary education net enrollment rate	84.8	91.4	73.1	67.9	35.7
	Primary education gross completion rate	68.6	85.2	79.9	68.3	38.0
	Lower secondary education gross enrollment rate	58.1	71.4	55.3	42.1	18.7
	Lower secondary education graduation rate	40.3	54.2	44.4	38.9	14.9
	Upper secondary education gross enrollment rate	39.0	48.3	27.9	21.9	7.3
	Upper secondary education graduation rate	34.6	43.1	35.5	32.2	6.9
6	Percentage of people with access to improved water	89.1	96.1	88.4	84.6	72.1
	Percentage of people with access to sanitation services	58.4	68.3	52.9	47.2	34.1
7	Percentage of population with access to electricity	72.0	88.0	65.3	57.7	46.8
8	Annual growth rate of real GDP per capita	-2.8	7.2	4.2	2.7	-4.6
9	Manufacturing value added as a per cent of GDP	19.6	26.0	20.8	18.6	20.5
	Manufacturing value added per capita	26.6	68.9	20.0	13.6	8.2
	Connections per hundred people to fixed broadband technology	1.2	11.7	10.8	10.1	6.9
	Connections per hundred people to mobile broadband technology	0.3	115.8	106.8	102.4	91.1
11	Urban population weighted fine particulate matter 2.5 levels in residential areas of cities with more than 100,000 residents	27.7	18.7	19.7	19.5	17.6
16	Number of victims of intentional injuries per thousand	0.12	0.06	0.09	0.09	0.60
	Years of life lost to intentional injuries per thousand	6.9	3.2	4.9	5.0	33.4
	Years of living with disability due to intentional injuries per thousand	0.56	0.32	0.54	0.53	1.44

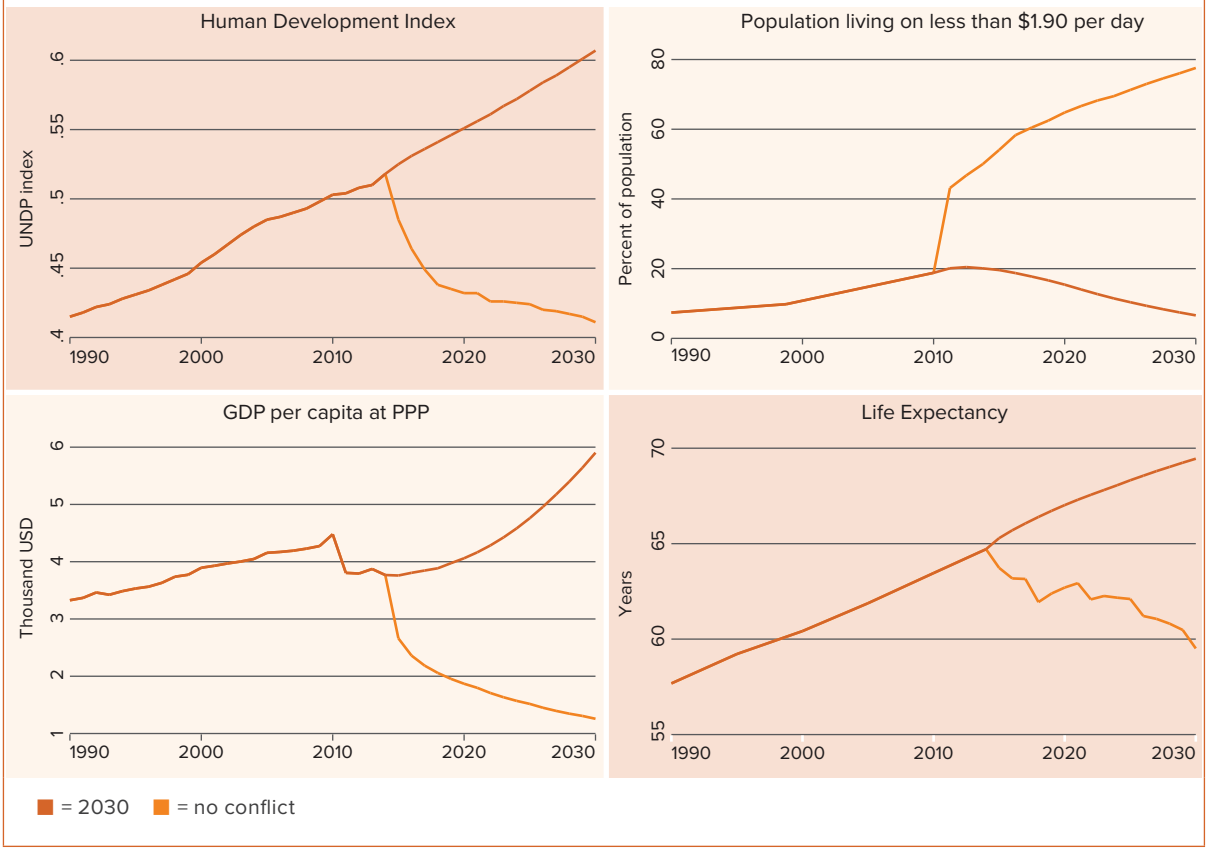
The war in Yemen has become a war on children. Nearly all indirect deaths are children under the age of five, who already account for six-out-of-10 total excess deaths between 2015–2019. If fighting continues through 2019, one child will die every 11 minutes and 54 seconds that would have otherwise lived in a *No Conflict* scenario. An additional 32 out of 1,000 babies born will die before reaching their first birthday due to conflict. And conflict will have caused an additional 1.6 million child-years in malnutrition.

We estimate that the burden shouldered by children accelerates over time. If war lasts until 2030, it will account for a child's death every 2 minutes and 24 seconds—or 600 deaths per day. Of every 1,000 births in 2030, 115 infants are projected to die within a year due to conflict. Eight-out-of-10 children are projected to be malnourished, this represents 3.3 million more than would be without conflict. In the scenario where conflict extends to 2030, conflict directly and indirectly causes the death of nearly 1.5 million children before their fifth birthday.

Beyond the decimation of a generation, the war is setting back human development and capabilities for those who do survive. Already the conflict has impoverished much of the population, with 75 per cent living on less than US $3.10 per day at the end of 2019 compared to 46 per cent in the *No Conflict* scenario.

The conflict has not only pushed more people into poverty, but that poverty has also become much more intense. The poverty gap, a measure of the average distance between actual income and a poverty threshold, is projected to increase by a factor of seven by the end of 2019. If the war extends through 2030, Yemen will be the poorest country in the world, with 88 per cent of the population living on less than US $3.10 per day and 78 per cent on less than US $1.90. By 2030, the depth of poverty is projected to be almost 12 times larger than in 2014 (61 times greater than the *No Conflict* scenario).

FIGURE 7 | *Select development indicators along the No Conflict scenario and Conflict 2030.*



Another way to measure impacts over time is using "person-years," a concept that measures both the length of time and number of people who are experiencing a developmental condition. For example, if 1,000 people experience poverty for three years each, that sums to 3,000 person-years in poverty. By 2019, the conflict has caused an additional 43.6 million person-years of extreme poverty compared with a *No Conflict* scenario. An extension of just three more years essentially doubles the suffering to 86.6 million person-years. And by 2030, the conflict will have caused 265.2 million person-years of poverty in Yemen, a level of suffering difficult to comprehend.

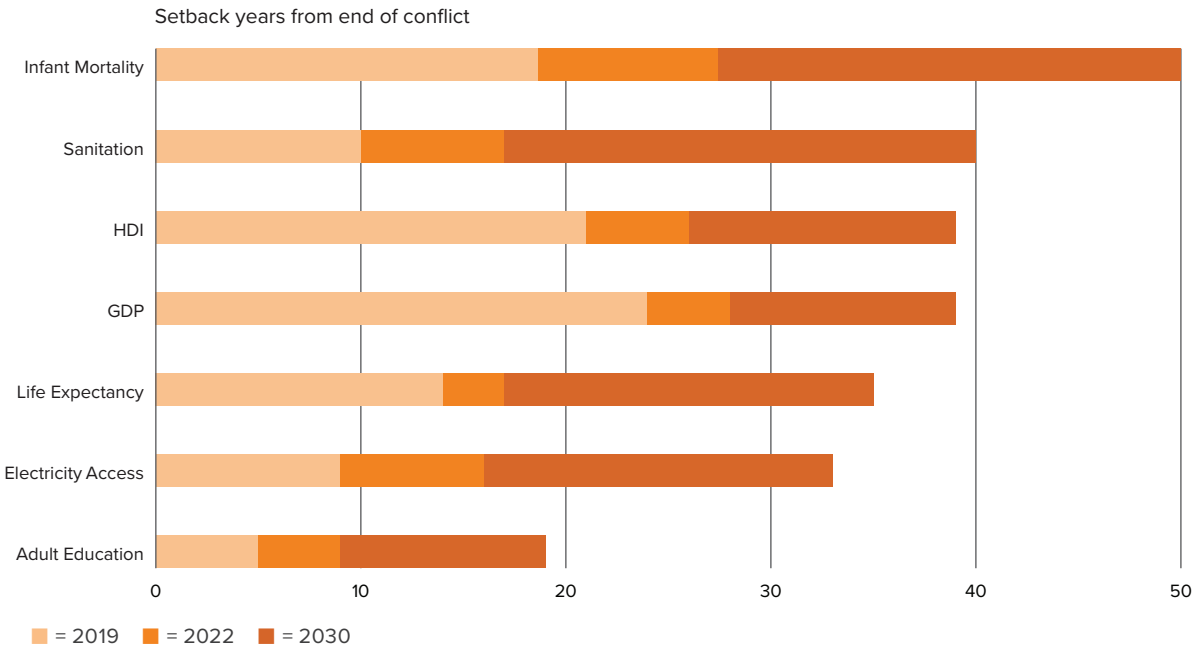
Deteriorating health and education systems have serious implications for Yemen's human development. Life expectancy has been reduced 4.3 years compared to the *No Conflict* scenario—a gap that grows to 5.5 years if the conflict goes to 2022 and 10 years if the conflict lasts until 2030. If the war ends at the end of 2019, half of all children and more than a third of the population will be malnourished. By 2030, 96 per cent of the population is projected to be malnourished, a level not yet seen in the 21st century.[171]

Educational attainment, measured as the years of education completed by the average Yemeni over 15, is already half a year less than in the *No Conflict* scenario. This sums to 10.3 million child-years of missed education. If the conflict lasts until 2022, the gap in average education between the conflict and *No Conflict* scenarios grows to a full year. And if it persists through 2030, the average Yemeni will have just under four years of education, nearly two years less than in the *No Conflict* scenario. With 57.4 million student-years of education lost, a Yemen at war in 2030 would have the third-lowest educational attainment in the world.

GDP per capita at the end of 2019 has already been cut in half relative to the *No Conflict* scenario. If the conflict ends in 2019, the cumulative missed economic output is estimated to be nearly US $89 billion—more than double Yemen's 2014 GDP. By 2022 GDP per capita falls to US $1,710 in a conflict scenario and the cumulative GDP lost grows to over US $180 billion. By 2030 it reaches US $657 billion with a GDP per capita reducing to US $1,260. This represents a US $4,650 reduction compared with the *No Conflict* scenario.

The HDI is a composite measure of human development comprising health, education and income. HDI has already fallen 15 per cent since 2014, and the gap between Yemen in conflict and a *No Conflict* scenario continues to widen. In this context, reductions in HDI reflect of the indirect impact of war that are disproportionately felt by women and children. If the

FIGURE 8 | *The "setback" impacts of conflict in Yemen across various indicators.*

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conflict lasts until 2030, gender-based HDI values for men are 28 per cent lower than the *No Conflict* scenario, while HDI for women is 45 per cent lower than the *No Conflict* scenario.

The conflict sets some development indicators back to levels not seen in decades. Figure 8 shows how many years in Yemen's history we have to look before we see developmental conditions similar to those produced by different conflict scenarios. Infant mortality, for instance, has already increased from 46.3 deaths per 1,000 live births in 2014 to 70 in 2019, a rate not seen in Yemen in 18 years. If the war continues until 2030, infant mortality is projected to double, to nearly 140—this is a setback of 50 years.

The figure illustrates how the war's consequences unfold as it persists. Of the indicators here, for instance, GDP experiences the greatest setback by 2019. The onset of a conflict disrupts economic growth and activity broadly and rapidly. As it drags on, war's impact on the economy is marginally less. In other areas, the impact is delayed. And even thought sanitation and electricity access are not as sensitive to the immediate onset of conflict, over time infrastructure is not maintained and people are displaced. At the same time, programmes to expand access are disrupted. This results in the setbacks for sanitation and electricity being much greater in 2030 than in 2019.

Adult education shows the shortest setback in Figure 8 because it is a measure of the average years of educational attainment *among adults*. Most adults in the population had already completed as much school as they ever would before the conflict began, so this measure changes very slowly. A setback of nearly two decades by 2030 translates to a considerable reduction in Yemen's human capabilities.

The 2030 Agenda emphasizes that "no one must be left behind."[172] Yemen was facing numerous development challenges even before becoming embroiled in a devastating civil war. As we see in the *No Conflict* scenario, the country was not on track to meet any SDGs by 2030, but Yemen was still making progress toward SDG achievements. The war has not only wiped out those fragile gains but has reversed development. Yemen's distance from many SDG targets is growing and Yemenis are increasingly left behind.

Moreover, the impacts of this conflict will scar Yemen's development far beyond 2030. While reconstruction is beyond the scope of this project, the road to recovery will be long and difficult. Infrastructure and physical capital have been destroyed and will need to be rebuilt. Millions are displaced, many of whom may find it impossible to return home. With so much of a generation malnourished, many of those who survive will grow up to be stunted, which has lifelong consequences. Stunting in early childhood is associated with lower levels of educational attainment, productivity and lost wages later in life.[173] And we estimate that if the war continues to 2030, it leads to an additional 13.1 million Yemenis stunted by 2050 because of the conflict.

Contextualizing the Conflict in Yemen with Previous Conflicts

This report has presented a methodology for understanding the developmental impacts of armed conflict in Yemen across multiple scenarios. We have used this framework to identify which aspects of development are most impacted by the conflict and have shown the magnitude of the setback in overall development. But the size of the impact is difficult to conceptualize and contextualize. How does the conflict in Yemen compare with other conflicts since the end of the Cold War?

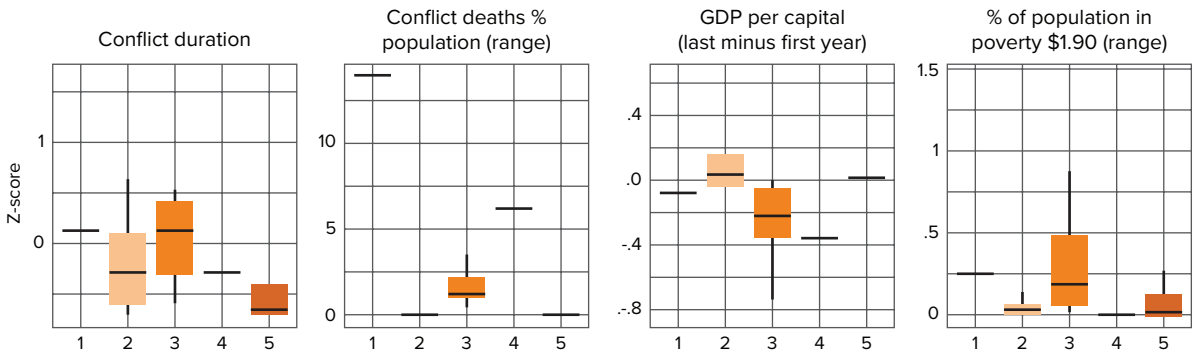
To contextualize the conflict in Yemen we conducted cluster analysis on previous conflicts. Clustering or classification algorithms take varying approaches to the same question: how close or similar is one row of data to others? In a two-dimensional scatterplot, the distance between two points can be visually determined quite easily. However, in data with dozens or even hundreds of dimensions or indicators, distance or similarity is impossible to deduce without help from classification algorithms.

For each conflict period, we computed summary statistics for various indicators related to conflict intensity and impacts on human and economic development (poverty, malnutrition, etc.).[3] We gathered data on 66 conflicts that have occurred since 1990 measuring conflict duration, magnitude, conflict mortality and other development indicators that capture the impact of conflict.

Next, we used three classification algorithms to determine the appropriate number of clusters: (a) k-means; (b) partitioning around medoids (also known as PAM); and, (c) hierarchical clustering. Clustering algorithms differ in how the number of clusters (or groups) is determined. For k-means and PAM, the analyst chooses the number of groups, and there are several quantitative tests to help guide this decision. These tests are each unique ways of measuring cluster performance. Data that is in the same group are reasonably similar, while each cluster is distinct from one another.

These algorithms identify five clusters that group all conflicts since 1990. Figure 9 shows the average cluster measurement for four indicators of conflict severity and impact, starting with the following: (a) conflict duration; (b) conflict deaths as a share of the population; (c) change in GDP per capita; and, (d) the percent of the population living in extreme poverty. Two clusters contain only one conflict each. These represent the

FIGURE 9 | *Plot of select cluster-defining variables.*



3 The unit of analysis for this approach is each unique conflict event since 1990. We used data from the Political Instability Task Force (PITF) to identify each country-year pair where an armed conflict occurred. Conflicts are distinct when found in the PITF data in non-consecutive years. For example, since 1990 Yemen has experienced two distinct armed conflicts—one single-year event in 1994 and the current conflict which began in 2004.

TABLE 5 | *Conflicts included in the high-impact, long-term cluster with Yemen.*

Country	Start	End
Azerbaijan	1991	1997
Tajikistan	1992	1998
Central African Republic	2005	*present*
Democratic Republic of the Congo	1992	*present*
Liberia	2000	2003
Sierra Leone	1991	2002
Iraq	2003	*present*

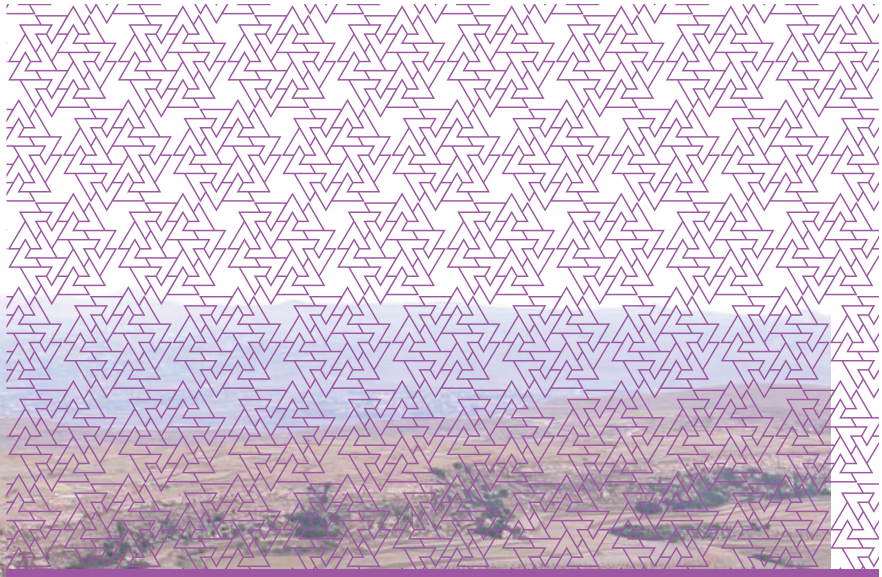
largest outlier conflicts since the end of the Cold War. In Figure 9 they are represented in Cluster 1: Rwanda (1990–1994) and Cluster 4: Syria (2011–present).

The current conflict in Yemen is grouped in Cluster 3. Of the three clusters containing more than one country (representing 96.9 per cent of conflict since the end of the Cold War), Cluster 3 includes the longest conflicts with the most deaths and largest impacts on development over the past three decades. Other Cluster 3 conflicts are identified in Table 5 and include some of the most impactful large-scale domestic conflicts since the end of the Cold War.

Cluster 2 is characterized by conflicts that occur in generally more developed countries that already have improved human development indicators such as extreme poverty. Examples here include Iran (2004), Thailand (2004), and Russia (1994). Cluster 5 includes conflicts with low death rates and short durations, like Madagascar (2009), Cambodia (1997) and Nigeria (2006).

We applied this clustering approach to the same dataset, but included projections of the Yemen conflict scenarios to test whether these projections change where this conflict fits into historical context. This analysis shows that—in the counterfactual scenario where conflict ended in 2014—the conflict would have been more similar to Cluster 2 (low death rates and low developmental impact). The escalation of conflict in 2015 moved it to Cluster 3. In all scenarios tested here with conflict ending in 2019, 2022, or 2030, the conflict in Yemen remains among Cluster 3.

This suggests that the conflict in Yemen is among the highest intensity conflicts since the end of the Cold War, and that escalation that occurred in 2015 was indeed a watershed moment.



CONCLUSION

The war in Yemen is a preventable humanitarian disaster that, if continued through 2019, will take the lives of nearly one-quarter of one million people. If that war continues it will continue to disproportionately kill children, mostly due to a lack of access to food, health services and infrastructure. It is already placed among some of the worst conflicts since the end of the Cold War.

If the conflict extends to 2030 the overall development in Yemen will have deteriorated significantly. By 2030, it is projected that nearly 80 per cent of Yemeni children will be malnourished, 66 per cent of the population will lack access to proper sanitation, 84 per cent of the population will lack proper access to safe water and 76 per cent of children will not be in school. There would be an additional 1.8 million deaths of which 1.5 million would be infants and children under five years of age. We estimate that one additional child will die every 2 minutes and 24 seconds by comparison to a *No Conflict* scenario. Armed conflict will increase the share of the population living in poverty by 63 per cent and reduce economic activity by US $660 billion, or over 18 times the size of the economy before the escalation of conflict in 2015.

The scale of suffering borne by the children of Yemen is devastating. The international community must come together to ensure peaceful resolution to the conflict in Yemen and promote a path towards recovery.

ANNEX 1: DATA ESTIMATES AND NOTES

Data collection in a conflict zone is notoriously difficult, and the data available for recent years in Yemen is of particularly poor quality and frequency. Of the data which has been collected in Yemen during the conflict, much of it is typically context-specific, collected at district or governorate-level, or collected to inform a specific project.

But IFs and certain other types of country-level integrated assessment modeling (IAM) platforms depend on broad country-level indicators. Due to the ongoing conflict in Yemen today, many of these indicators are of questionable quality for several reasons. For one, some data have a moving average applied to them before they are disseminated, which may smooth out the acute effect of conflict onset or escalation. Second, some data with limited historical availability are subject to hole-filling procedures. If the most recent observed data point is from a year prior to the current conflict, it may miss the disruptive effect of conflict entirely. Finally, even estimates like GDP growth can be questioned when conflict may disrupt the core in-country reporting bodies responsible for collating information and estimating sector-based productive flows.[4]

We completed an extensive survey of available data pertaining to Yemen during the conflict years (2015 to present). Because the data is used to calibrate the IFs model, it was critical to determine which figures best represent the situation in Yemen today and in recent years. The following sections describe that decision process through a survey of data methodologies, strengths and weaknesses, for three key variables: conflict deaths, GDP growth, and poverty. A review of the calibration methodology and other assumptions made can be found in Annex 3.

Conflict Deaths

As the conflict in Yemen has continued, various organizations involved in reporting conflict deaths within Yemen have come up with increasingly diverging death counts. The five main sources reporting on conflict death count in Yemen are:

1. Armed Conflict Location & Event Data Project (ACLED)
2. Uppsala Conflict Data Programme (UCDP)
3. Office of the United Nations High Commissioner for Human Rights (UN OHCHR)
4. World Health Organization (WHO)
5. Political Instability Task Force (PITF)

The table below displays the conflict death count by year for each of these organizations.

There are a few main splits in the methodology used to collect these figures. First, the WHO figures are sourced from health facility reporting, thus they likely underestimated fatalities, since "many more" conflict deaths are likely to have occurred before reaching a health facility.[174] This is unsurprising, as over half of the country's health facilities have stopped functioning since 2015.[175] The number coming out of UN OHCHR reflects an even lower count than WHO figures, with a note that "the real figure is likely to be significantly higher."[176]

The Uppsala Conflict Data Program (UCDP) is a well-established research initiative housed at the Department of Peace and Conflict Research at the University of Uppsala. The figures in the below table are from the "Georeferenced Event Dataset" (highest level of disaggregation), which was used to filter for conflict deaths in Yemen across the years needed (2015–2018). UCDP primarily uses search strings run through media aggregators in order to collect media-reported incidents of conflict fatalities, with a secondary filtering of sources in order to control "potential

4 Institutions such as the IMF and World Bank have stopped reporting figures from Yemen and some other conflict-afflicted countries in their flagship annual macroeconomic reports, indicating a significant level of uncertainty around the macroeconomic reality in these countries today.

TABLE 6 | *Counts of conflict-related deaths in Yemen by reporting organization.*

Data source	2015	2016	2017	2018
ACLED		15,271	16,832	31,035
UNDP	6,984	3,178	2,530	
UN OHCHR			6,660*	
WHO			9,245†	
PITF	1,685	836	582	505

*The WHO figure shown is a cumulative total of conflict deaths from 27 April 2015–31 December 2017.

† The UN OHCHR figure shown is a cumulative total of conflict deaths from March 2015 to August 2018.

TABLE 7 | *Estimates of conflict-related deaths by year from the UCDP.*

Year	"Best" estimate	Lower bound	Upper bound
2014	1,660	1,660	2,046
2015	6,778	6,647	7,695
2016	2,557	2,555	2,603
2017	2,317	2,317	2,564
Total	13,312	13,179	14,908

interests of the source in misrepresenting violent events."[177] The methodological overview of the project notes that "it is quite likely that there are more fatalities than given in the best estimate, but it is very unlikely that there are fewer. The fatality estimate is thus best interpreted as creating a baseline."[178]

UCDP further notes that the conflict fatality estimates may be low in comparison with other organizations because several criteria can disqualify an event from being coded into the UCDP database. These include: (a) "if it is unclear which actor was involved, or the status of that actor (e.g. level of organization); (b) unclear status of the incompatibility (for intrastate and interstate conflict events); (c) uncertainty about whether fatalities occurred; (d) too little information to exclude the possibility of double-counting; or, (e) event descriptions which do not provide sufficient context to meet coding requirements."[179] UCDP provides an upper and lower bound on their death estimates, as well as a highest confidence value.

Among the sources reviewed here, ACLED reports the highest count of conflict-related fatalities by far. ACLED publishes a host of methodological documents and codebooks on their website, as well as a Yemen-specific methodological overview. The methodology is like that used by the UCDP as far as triangulation of death counts, source bias consideration and filtering, etc. However, ACLED does not have the same criteria that UCDP does concerning the need to know both actors in a conflict event to code that event. Thus, a meaningful stream of conflict-related deaths is potentially left out of UCDP official estimates, due both to the traditional obstacles associated with reporting casualties in conflict zones as well as challenges that are specific to Yemen.[180]

PITF estimates are very low compared to those from the other organizations. The PITF database is focused on the quantitative extent of "the deliberate killing of non-combatant civilians in the context of a wider political conflict",[181] meaning that figures from PITF are intended to represent civilian casualties of armed conflict. The source data, however, will account for uncertainty regarding whether a conflict victim might be a non-identified combatant or similar. PITF seems to have less stringent criteria around source-bias consideration compared to UCDP. However, there is the additional

TABLE 8 | *Conflict death figures used to calibrate the IFs model for this project.*

Data used for IFs calibration	2015	2016	2017	2018
Conflict-related fatalities	6,778	15,271	16,832	31,035

criteria that any event logged must have a minimum of five non-combatants reported as being killed, excluding cases of targeted killings. Common reasons for case rejection are reporting on an incident that falls below the five-person death threshold and reporting on killed combatants. This, and its focus on non-combatant deaths, may explain PITF's low estimate.

Because ACLED has less restrictive exclusion criteria than UCDP, we determined that ACLED's data are more representative of the totality of human life lost in Yemen during the conflict, from 2016 forward. However, ACLED has not yet reported 2015 numbers, so we use UCDP data for model calibration in that year. The full four-year set of conflict death figures used for model calibration are in the table below.

GDP Growth Rates

GDP growth rate figures were collected from the following institutions, following a review of the relevant literature and databanks:

- IMF World Economic Outlooks (WEO)
- World Bank World Development Indicators (WDI)
- World Bank Macroeconomic Outlook
- CIA World Factbook
- United Nations Statistics Division (UNSD)
- United Nations Department of Economic and Social Affairs (UN DESA)
- Yemen's Ministry of Planning and International Cooperation (MoPIC)

GDP growth rate figures reported from these institutions are accompanied by a relatively high degree of uncertainty, due to: (a) the apparent lack of a fully operational Central Statistical organization in Yemen;[5] (b) use of an out-of-date System of National Accounts methodology;[6] (c) the dearth of data and lack of reliable methodology or sourcing documentation upon which to base or benchmark estimates; (d) the general difficulties of data collation under conflict conditions; (e) the absence of a recent base year for price estimates in Yemen;[7] and, (f) disagreement over estimates between major reporting institutions. The estimates we collected are listed in the table below.

The International Monetary Fund World Economic Outlook (IMF WEO) projections rely on IMF staff-calculated and/or collected historical data and estimations dating back to 2008, the last year when current data was available from this source for Yemen per the IMF WEO methodology.[182.8] The only other country for which the historical data is more out of date is Eritrea (2006). In contrast, the United Nations Statistical Division (UNSD) GDP growth rate data available from the UN System of National Accounts (SNA) database reflects that the last year that produced

5 The website of Yemen's CSO (http://www.cso-yemen.com/) is defunct as of the publication of this report. While other organizations cite CSO data and correspondence in their publications from time to time, the current operating capacity of the CSO is unknown.

6 The SNA version currently employed in Yemen, per the IMF WEO, is the 1993 version. The recommended version is 2008.

7 IMF WEO data documentation indicates that the base year currently used for pricing estimations in Yemen is 2009. For National Accounts, the base year is 1990. The World Development Indicators (WDI) metadata note for GDP growth rate estimation advises that "using an old base year can be misleading because implicit price and volume weights become progressively less relevant and useful."

8 The IMF Yemen country office was reached out to for clarification surrounding methodology, but at the time of writing of this report, no response was forthcoming.

TABLE 9 | *Survey of annual GDP growth rate data for Yemen, by reporting organization.*

Organization and Series reported in publication	2015	2016	2017	2018*
CIA World Factbook *GDP growth rate (constant 2010 dollars)*	-16.7	-13.6	-5.9	
UN Department of Economic and Social Affairs (UN DESA) *Real GDP growth rate*	-28.1	-9.8	-7.5†	-4.3
UN Statistics Division (UNSD) *GDP growth rate (constant 2010 dollars)*	-30.3	-14.8	-5.9	
World Bank (2017: Policy Note #2) *Real GDP growth*	-28.1	-9.8	5	
World Development Indicators (WDI) *GDP growth rate (constant 2010 dollars)*	-16.7	-13.6	-5.9	-2.6
International Monetary Fund (World Economic Outlook) (IMF WEO) *Real GDP growth rate*	-16.7	-13.6	-5.9	-2.6
Ministry of Planning and International Cooperation (MoPIC) *Real GDP growth rate*	-30.3	-14.8	-10.9	

*All 2018 figures are estimations or projections. † The 2017 figure from UNDESA is noted to be a 'partial estimation.'

usable SNA data was 2016, much more recent than the IMF database.[183] UNSD uses the IMF WEO figure of -5.9 for the year 2017.

The Ministry of Planning and International Cooperation (MoPIC) in Yemen releases monthly socioeconomic update reports; a December 2017 issue describes the macroeconomic situation in Yemen.[184] Here, MoPIC's growth rate figures match those of the UNSD for all years except 2017. While UNSD reports the IMF WEO growth rate of -5.9 for this 2017, MoPIC reports a growth rate of -10.9. The report cites the SNA 2016 from Yemen's Central Statistics Office (CSO) as being the source of the data used to produce the historical (up to 2016) estimates and uses pricing data from 2017 to estimate the real GDP growth value for that same year.

As CIA World Fact Book and World Development Indicators (WDI) data reflects the same year-on-year estimates as the IMF WEO; it is assumed they source from the same out-of-date SNA data. UNDESA maintains its own system of yearly country surveys for attaining SNA data which appears—based on the review of the methodology—to be the most up-to-date.

For this report, we elected to use growth rate figures from UNDESA,[9] modified to take a value of -5.9 in lieu of the -7.5 figure for 2017 noted to be a partial estimation. While the -5.9 figure is included in the IMF/WDI sources which were potentially based on old SNA data, this figure is also reflected in the UNSD numbers which are noted above to be thought to be from the most recent data, and it is not noted there to be estimation. The full series of GDP growth rate point estimates which we input exogenously into the IFs system are displayed below.

TABLE 10 | *GDP growth rate figures used to calibrate the IFs model for this project.*

Data used for IFs calibration	2015	2016	2017	2018
Real GDP growth rate	-28.1	-9.8	-5.9	-4.3

9 Results from a World Bank-conducted study using satellite imagery data to estimate GDP contraction during the first months of conflict seem to be roughly supportive of 2015 figures reported from UNDESA. See: Tiwari, Sailesh. "Yemen Poverty Notes." Working Paper. The World Bank, 1 June 2017.

Poverty

Poverty estimates for the years 2015–2018 come almost exclusively from simulation or modeling and estimation exercises, as a nationally-representative household budget survey (HBS) was most recently taken in 2014.[185] The 'official' estimates of macroeconomic indicators—like the World Development Indicators compiles—for example, correspond only to those years where nationally-representative surveys were undertaken in Yemen: 1998, 2005, and 2014. Further complicating the matter is the question of comparable methodology for survey rounds that exist almost a decade apart.[186]

Through a survey of the literature, we found three main sources of poverty simulation data as it pertains to Yemen and additional reporting of poverty rates for one year (2017) from MoPIC.

Tiwari et al.[187] of the World Bank Group conducted a microsimulation study to project estimated poverty headcount and associated inequality coefficients. They utilized the 2014 HBS data on poverty, as well as the real GDP growth rate estimates from the IMF [-0.2 (2014); -28.1 (2015); and, -9.8 (2016)]. They estimate that in 2016, poverty rates in Yemen (for which the national poverty rate is roughly equal to US $3.10 a day in 2011 US dollars[10]) are somewhere in the range of 62–78 per cent, depending on model specification assumptions.

Two reports from Arezki et al.[188] of the World Bank provide a similar workable range for poverty figures based on two rounds of estimation, one in April 2018 and the other in October 2018. The two rounds of estimation use very different GDP growth rates assumptions, which is helpful for our purposes in determining general upper and lower bounds of poverty estimates, sensitive to different input data on GDP growth rate.[11] The input data on GDP growth rate in the April study seems potentially overestimated given the GDP discussion found on the previous pages of this report, but can be useful in determining an upper bound of estimates.

TABLE 11 | *Microsimulation exercise results from Tiwari et al. (2017)*

Tiwari et al. (2017)	2014	2015	2016
Real GDP growth rate *(at constant market prices)*	-0.2	-28.1	-9.8
National poverty rate *(445 Yemini Rial a day, 2014)*	48.6	-	76.9
Gini index	36.7	-	48.9

TABLE 12 | *Microsimulation exercise results from Arezki et al. (April 2018).*

Arezki et al. (April 2018)	2015	2016	2017 *(estimate)*	2018 *(forecast)*
Real GDP growth *(at constant market prices)*	-37.1	-34.3	-13.8	-0.5
International poverty rate *(US $1.90 day in 2011 PPP)*	50	76.3	82.9	83.9
Lower middle-income poverty rate *(US $3.20 a day in 2011 PPP)*	79.7	92.2	94.7	95.1
Upper middle-income poverty rate *(US $5.50 a day in 2011 PPP)*	93.5	98.2	99	99.1

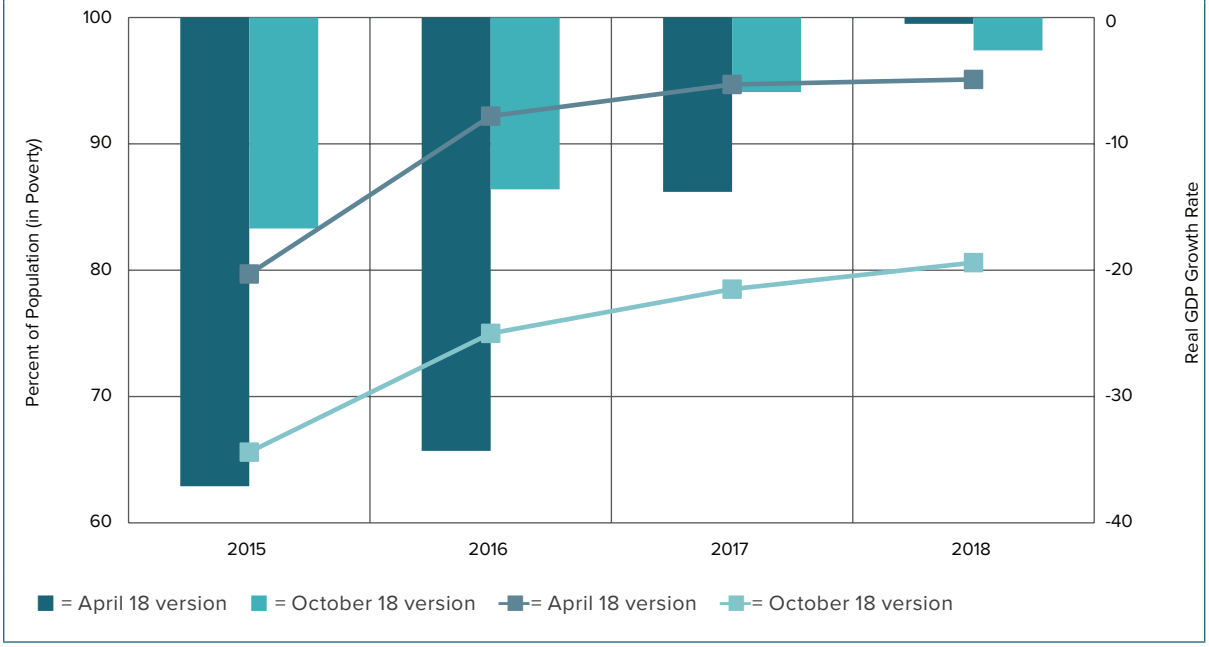
10 Calculation performed using reverse estimation from PovCalNet: http://iresearch.worldbank.org/PovcalNet/home.aspx

11 The determination for GDP growth rate point estimates to use in this study was made separately (see previous data note) from the consideration for poverty rate data here. In the methodology section of the main report, GDP growth rates are noted to be a Round 1 calibration series, while poverty is calibrated in subsequent rounds. For this reason, we use poverty rate data from the studies discussed here as guidelines, but not hard inputs into the IFs system. The poverty estimations overviewed in these studies are likely sensitive to GDP growth rate assumptions, as they would be in IFs. The option of using poverty rates as a benchmark instead of inputs does not require harmonization between GDP growth and poverty rates from the sources overviewed in our model calibration, given the wide range of GDP estimates available between the three studies.

TABLE 13 | *Microsimulation exercise results from Arezki et al. (October 2018).*

Arezki et al. (October 2018)	2015	2016	2017 *(estimate)*	2018 *(forecast)*
Real GDP growth *(at constant market prices)*	-16.7	-13.6	-5.9	-2.6
International poverty rate *(US $1.90 a day in 2011 PPP)*	30.4	42.6	48.2	51.9
Lower middle-income poverty rate *(US $3.20 a day in 2011 PPP)*	65.6	75	78.5	80.6
Upper middle-income poverty rate *(US $5.50 a day in 2011 PPP)*	87.9	91.8	93.2	94

FIGURE 10 | *GDP Growth and Associated Poverty Figures, Arezki et al. (2018) two studies.*



The October simulation, in comparison with April, uses a more conservative set of GDP growth rate estimates and thus provide more conservative, but still significant, estimates of poverty rates.

The figures from these two studies, for the years 2016 indicate a US $3.20 a day poverty range of 75–92.2 per cent for the year 2016. This is a bit more severe an estimate than the range from the Tiwari et al. piece (reporting figures that roughly correspond to US $3.10 a day).

In its December 2017 Socioeconomic Update, MoPIC attributes a poverty estimate of 78.85 per cent in 2017, up from 49 per cent in 2014, to the CSO in Yemen, but does not provide poverty line that distinguishes between current and constant prices.[189] However, the figures are like those used by Tiwari et. al and the US $3.10 a day estimation provided by the October 2018 Arezki et. al study.

PovCalNet, the World Bank's online analysis tool for global poverty monitoring, provides the following poverty estimates for 2014 in Yemen: 52.22 per cent of the population at a rate of US $3.20 a day and 59.45 per cent of the population at a rate of US $3.52 a day. These figures suggest that from 2014–2015 there was an increase in poverty of 13 percentage points (from the October 2018 Arezki et al. simulation). This seems reasonable considering reports of widespread loss of livelihood since the beginning of conflict.[190]

In calibration rounds of the International Futures system, when a user calibrates the model to a given poverty line, a lognormal distribution of poverty—informed in shape by the Gini coefficient for a given year—is imposed and utilized to fill in values for any other given poverty line that the user specifies. In this study, we elected to impose the Gini coefficient of 0.49 that is reported in the Tiwari et al. study and use the three poverty simulations (Tiwari et al. and Arezki et al., Oct.) as an acceptable "range" and/or "target" point estimates for poverty projections from IFs to fall around.

We found that on the initial calibration round for the model, the US $3.20 poverty values projected from IFs (along the *Conflict 2030* pathway) falls within the range generated from a consideration of available studies for the years 2015 and 2016, while the US $1.90 poverty values fall within the same range for the years 2015, 2016, 2017 and 2018. Additionally, all point values for all years and both poverty lines fall below the Arezki et al. April study (with more severe GDP growth decline assumptions), providing confidence that we are not exceeding an upper threshold of estimation which might be interpreted as unreasonable. We interpret this as providing sufficient confidence in the IFs poverty projections to forgo further calibration rounds.

TABLE 14 | *Poverty figures used to benchmark the IFs model estimates for this project.*

Poverty line values generated in IFs calibration round and reference series *(percent of population)*	2015	2016	2017	2018
IFs Estimates *(US $1.90 day in 2011 PPP)*	43.14	46.76	49.99	54.05
IFs Estimates *(US $3.20 a day in 2011 PPP)*	70.4	70.8	71.8	73.7
Arezki et al. estimate range *(US $1.90 a day in 2011 PPP)*	30.4–50.0	42.6–76.3	48.2–82.9	51.9–83.9
Arezki et al. estimate range *(US $3.20 a day in 2011 PPP)*	65.6–79.7	75.0–92.2	78.5–94.7	80.6–95.1
Tiwari et al. estimates *445 YER a day (~US $3.10 a day)*	62.75	62–78		
MoPIC point estimate *445 YER a day (~US $3.10 a day)*			78.85	

ANNEX 2: MODELING ASSUMPTIONS

Conflict Scenarios

For each conflict termination year scenario overviewed below, the strategy for calibration in IFs is essentially the same. We conduct a thorough data search for input or benchmarking data (depending on calibration round) and use these estimates to inform the parameterization of different variables within the model to more accurately reflect conflict history after the model "Base Year" (in this study, from 2015–2019 where later years of data are available). This parameterization is then typically held constant across the conflict horizon for a given scenario—except in the case of Conflict Deaths and GDP growth rates, which are both discussed in the main text and in this section below. After the last year of conflict for a given scenario, the parameter adjustments are relaxed back to the model base run values for the remainder of the projection horizon.

For the *No Conflict* scenario, the model base run can operate with minimal parametric adjustments, save for around variables associated with societal violence from conflict and probability of conflict onset.

CALIBRATION FOR CONFLICT DEATHS AND MAGNITUDE

In the IFs system, we relied on three main parametric controls to simulate the scale and intensity of the Yemen conflict presented in this report.

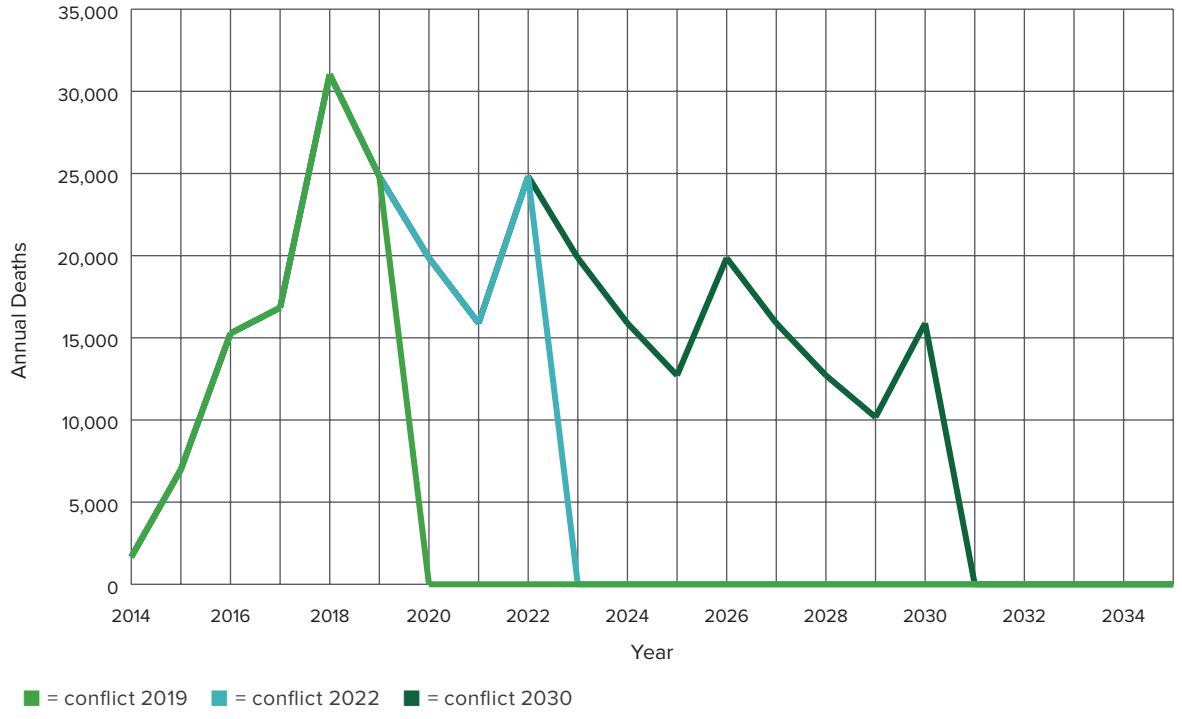
The first is an exogenous parametric control on conflict deaths. We used this control to calibrate the conflict deaths in the No Conflict scenario for years 2015–2018 according to ACLED reporting data, and thereafter according to modeling assumptions taken on the frequency pattern and intensity of conflict deaths. We modeled three "flare-ups" in conflict over the longer-term scenario (conflict termination in 2030). This assumption tracks conceptually with the year-on-year volatility often seen in long-term conflicts, but is simulated with a parameterized decay in magnitude combined with a periodic flare-ups every four years whose magnitude also decays over time (see Figure 11). For the short- and medium-term conflict scenarios, we've modeled a peak in conflict deaths (2019) and one additional flare-up (2022), respectively.

The second is an exogenous parametric control on conflict "magnitude," which is benchmarked to historical data from the Political Instability Task Force/Center for Systemic Peace (CSP)[191] project on state failure.[12] We made this determination by comparing the trend in magnitude acceleration and death patterns after conflict onset in Yemen to historical conflicts covered by the CSP database, where we found high similarity between Yemen, Sierra Leone and Iraq. These countries also showed similar conflict length to each other (as well as similar dynamics in magnitude during early years) and clustered in the same group as Yemen in the clustering exercise in this report (see Table 5).

These latter two conflicts both peaked around or above magnitude of six and were similar both in the low initial conflict intensity and a 'phase shift' characterized by a rapid transition to higher conflict intensity. While we are interested here in exploring the differential effects of conflict on development, we did seek to limit the number of assumption vectors by which we might introduce additional uncertainty into interpretation of results. Thus, we assume that the conflict magnitude of six stays constant for all conflict years across scenarios. This has the effect of simplifying interpretation of results (not sensitive to changes in an index measure), as well as displaying a pattern which

12 Internal to the IFs system, conflict magnitude is consolidated across the four conflict types to compute an average expanded index based upon inclusive weighting of the subcomponent measures available for each conflict designation from PITF. This consolidated conflict magnitude score is used to initialize the IFs projections for conflict magnitude and is also what was used historically for cross-country benchmarking and validation.

FIGURE 11 | *Conflict magnitude assumptions*



is also seen across some historical conflicts with similar characteristics as Yemen (prolonged periods of 'stable' conflict magnitude).

The third is an instrumental parameter that describes the likelihood of conflict for projection years. For the purposes of this study, we set this parameter to a value of 1 (conflict = true) for the full conflict horizon for a given scenario.

CALIBRATION FOR GDP

GDP is calibrated in the model by adjusting two parametric controls, one which allows the use of an exogenous GDP growth rate series to be imposed on the model, and another which allows manual control over GDP growth rate values. For the initial historical years (2015–2018) GDP growth rates are adjusted to reflect values from UN DESA (see Annex 1). For subsequent years, GDP growth rate tracks the pattern in rate of change of conflict deaths pertaining to the scenario in question (with opposite valence).

GDP growth is assumed to not exceed zero in any conflict year, but does approach zero rapidly, and remains at an average of -2.3 over the conflict horizon in the 2030 conflict termination scenario. It was elected to not model any years reflecting positive growth figures during conflict years. While there are historical examples of economic growth under conflict, the dynamics of growth under conflict are very unclear.[192]

In a recent study which looks at the general effects of intrastate conflict on GDP growth, on average, growth does not tend to become positive until the first year of recovery.[193] The years which are shared between each scenario are modeled with the same growth rates. Internal model dynamics can take over after the last year of conflict in the model, otherwise growth rates are suppressed according to the information above.

CALIBRATING POVERTY

IFs contain no exogenous parameter controls for adjusting the levels of poverty in a country. Poverty calculations are made in the model by assuming a log-normal distribution of household consumption shaped by domestic Gini index values and reconciled in initial years with poverty data. For this reason, we adjust the Gini index over the conflict horizon to tune the poverty rates to figures that we have vetted as being representative of the current situation in Yemen (see Annex 1). After the desired poverty levels are reached

for the last year of data available for poverty rates, the Gini index is held constant at that value across the conflict horizon.

The use of Gini in this way implies a Gini that may or may not be in line with the situation in Yemen today, although no Gini value has been reported for Yemen since pre-conflict years and reporting of the Gini index under conflict context for any country historically is very rare. We are thus uncertain and agnostic as to the actual extent of inequality within Yemen today, something that this report does not address, and thus we simply use Gini instrumentally here to calibrate poverty figures.

CALIBRATION FOR AGRICULTURE

We calibrate agricultural production values in these scenarios with data from the FAO.[194] There is no exogenous model parameter on agricultural production within the IFs system. Rather, changes must be made most proximately via exogenous parameter adjustments to agricultural yield values or agricultural land values. Agricultural yield parameters give more direct control over final production values within the system. Thus, it was elected to adjust yield values to make commensurate final crop production values in FAO historical data with early year projection values in scenarios. After 2018, we elected to hold the parameter on yields constant (repressed relative to current path) over the conflict horizon.

We've adjusted agricultural import flows via a user-controllable parameter to reach levels commensurate with values reported by FAO/GIEWS[195] and the World Bank[196], which suggest that import volume of essential commodities remained relatively stable across the conflict period. This parameter is thus used here in an instrumental way, to reconcile import volume with what was previously suggested in the IFs base case.

CALIBRATION FOR EDUCATION

The Global Partnership for Education project[197] advises that Yemen had 6.5 million school-age children in 2018, while UN Office for the Coordination of Humanitarian Affairs (UN OCHA) reports a figure of 7.5 million.[198] This appears to correspond to the number of students within the compulsory education system (6–14 years of age) per the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics categories, which IFs estimates to be around 7.24 million in 2018. The UN OCHA Humanitarian Response Plan for Yemen[199] suggests that:

1. There was an extended period of non-payment to school officials in 2017/2018 in 13 of 22 governorates in Yemen, causing significant school delays/disruptions.

2. Between 20 per cent and 33 per cent[200] of schools in Yemen have suffered damage or occupation to the extent of being unfit for use.

3. 4.1 million school children need assistance to continue schooling.

These above figures imply that, even if the broader cohort of children aged 6–14 are considered—an additional 57 per cent of children are at risk of losing education on top of the 28 per cent that are already out-of-school. This implies a worst-case scenario total for the immediate future of 85 per cent of children out-of-school, should the state of the education system continue to deteriorate. We interpret this 85 per cent figure to be an upper limit of a potential worst-case scenario for the medium term—and use it to inform our scenario intervention into the education system.

The education system in IFs can be conceptualized as a "pipeline", where cohorts of school age students move through successive stages of education: primary, lower secondary, upper secondary and tertiary. There are exogenous parameters on intake, graduation and transition rates at each level, which further affect the upstream flows of education. For this study, we reduce survival and intake/graduation (by 50 per cent) to: (a) model a proxy for the combined impacts of infrastructure damage; (b) reduced schooling hours; (c) occupation of schools; (d) reduced ability to pay for child schooling; (e) reduced staff and classroom time associated with non-payment within the school system; (f) the size of the pool of children out-of-school; and, (g) at risk for losing access to the education system. We hold this adjustment constant over the conflict horizon to be agnostic concerning the timeline and potential for repair and recovery of the education system while under conflict or further deterioration.

CALIBRATION FOR ENERGY

The energy model in IFs represents energy production and flows from six major sources: oil, gas, coal, hydro, nuclear, and renewables. We model an import limit on energy to Yemen that is set to converge on a value that is not to exceed the average monthly figures (translated to yearly) reported for fuel imports by the World Bank.[201] This limit extends throughout the conflict horizon of the respective scenario. Years prior to 2017 will see slightly higher values than average monthly figures suggest because of the high uncertainty associated with import values reported from different organizations.

Production figures were calibrated using a user-controllable parameter on total energy production. Production values were pegged generally to average daily production figures for oil reported by the Energy Information Agency (EIA),[202] re-estimated to yearly intervals—about .005 billion barrels of oil equivalent (billions of barrels of oil equivalent). This value is held constant over the conflict horizon to remain agnostic about the geographic dispersion of conflict and its effect on energy production operations, something that this report is not intended to address.

CALIBRATION FOR WASH

We use a point estimate from REACH[203] for the year 2016 to compare to IFs piped water coverage numbers and find the difference to be negligible (0.8 per cent). For sanitation access values, we utilize a point estimate for 2016 from UN OCHA of 11.6 million people in acute need of access to sanitation services,[13] which corresponds almost exactly with the sanitation figures in the IFs system. Because of the proximity of these two point estimates under conflict, as well as the dearth of reliable time series estimation, we make no further calibration to the WASH sector for projection years.

CALIBRATION FOR NUTRITION

We benchmarked model projections under conflict years for prevalence of Severe Acute Malnutrition (SAM) in the population, as well as child undernutrition, and use prevalence of undernutrition data from FAO for undernutrition in the wider population. SAM estimates from the model years match which UNICEF estimates from the years 2016–2018.[204] FAO estimates prevalence of undernutrition values to 2017, with a three-year moving average applied to the time series to smooth data.[205]

We use these data to benchmark our projections—IFs projections are slightly conservative compared to FAO data, but prior calibration rounds of the model result in less than a 10 per cent difference in 2017 between the point estimate of undernutrition headcount in

13 This is distinct from people in need of basic access, which also is noted to capture those people who have access but are currently at risk of losing access.

Yemen. For child malnutrition estimates, IFs are slightly conservative as well—Eshaq et al.[206] report that child malnutrition stood at 50 per cent of the child population, while IFs reports 46.5 per cent for the same year. This suggests that, while IFs are slightly conservative across both measures for initial years, internal dynamics for projection years are in-line with data collected.

CALIBRATION FOR FDI

We made exogenous adjustments to both internal and external stocks of foreign direct investment (FDI) in the model, in order to bring year-on-year FDI flows in line with time series data collected from UN Conference on Trade and Development (UNCTAD).[207] Here, the UNCTAD data is used as a target in order to calibrate year-on-year FDI flows into a more acceptable range with historical estimates under conflict years for Yemen.

CALIBRATION FOR REVENUES

We made adjustments to year-on-year values of government revenues (central plus local) in order to more closely reflect estimates of government revenue streams (as per cent of GDP) from the World Bank.[208] Here, the World Bank estimates are used as target values in order to get year-on-year revenue flows into a more acceptable range with WDI estimates of revenues under conflict years for Yemen.

CALIBRATION FOR MIGRATION

IFs initializes migration projection based on net migration rates on a country-by-country basis. Net migration rates from the UN Population Division (UNPD) World Population Prospects (WPP)[209] are typically used within the IFs system as an exogenous series. Despite the severity of the conflict in Yemen today, most data sources continue to report net migration as negative in the country, meaning that the year-on-year inflow of immigrants exceeds the year-on-year outflow. The numbers compiled by the World Bank's World Development Indicators for 2017 are not substantially different than the 2017 values from the UNPD WPPs 2017 revision—thus for this project we elected to default to the UNPD WPP migration rates.

No Conflict Scenario

CALIBRATION FOR VIOLENCE

In IFs, there exist several parameters around conflict deaths, intensity/magnitude, probability, as well as societal violence more generally. For the No Conflict scenario, we adjust parameters surrounding the level of societal violence from conflict and terror categories to reduce to zero. Additionally, we adjust the parameter for the probability of internal war occurrence within Yemen to reflect a value of zero over the scenario horizon.

CALIBRATION FOR GDP

No exogenous assumptions were made concerning GDP growth rate in the No Conflict scenario. Rather, endogenous model relationships determine the baseline projection for GDP growth rate in Yemen.

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incurred directly and immediately from all wars in 1999. This impact works its way through specific diseases and conditions and disproportionately affects women and children.We thank the Weatherhead Initiative on Military Conflict as a Public Health Problem, the Ford Foundation, and the World Health Organization, NIA (P01 17625-01

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