

# TECHNICAL ASSESSMENT FOR FAMILY PLANNING AND UNIVERSAL EDUCATION

SECTOR: HEALTH AND EDUCATION

AGENCY LEVEL: INDIVIDUAL AND COMMUNITY

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\*Note: For some of the technical reports, the result section is not yet updated. Kindly refer to the model for the latest results.

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## EXECUTIVE SUMMARY

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As of 2021, the global human population stands at an estimated 7.87 billion people. Based on medium-variant population projections from the UN Population Division, this number is still growing, though slower than before; and if the current trajectory continues, the world will be home to 10.9 billion people by 2100.

In the context of climate change and GHG emissions, more people equates to more consumption, production and demand for resources, and consequently more GHG emissions. Slowing the momentum of rapid, unchecked population growth through a rights-based approach, therefore, is a significant factor in reducing GHG emissions and the negative human impact on the environment, though it is important to recognize that regions of the world where population growth is high are not always the same regions where emissions are highest.

Among factors influencing population growth, universal access to a quality education, as well as reproductive health-specific education are predominant. In most all contexts, education influences timing of marriage, births and desired family size. Women and men with more schooling tend to delay marriage and childbearing longer, and have fewer children than those with less education. When coupled with improved access to voluntary family planning and SRHR services, especially in countries where the unmet need for contraception is high or current demand is low, women and men will be equipped with the knowledge and autonomy to better plan and space their families. Unintended pregnancies and consequently unwanted births can be averted and total fertility rates would begin to decline, thereby reducing future unchecked population growth and consequently GHG emissions globally, through lowered demand for goods and services.

Based on the latest data available from the UN Populations Division, the adoption of Project Drawdown's Health and Education solutions—ensuring universal access to quality education for all girls and boys, and access to voluntary family planning services for all women and couples—will result in an estimated reduction of **69.9** GTs of GHG emissions by 2050. To achieve this, however, will require global, ambitious and concerted efforts in addressing and overcoming the barriers to education and SRHR that still exist in many regions of the world today.

# 1 LITERATURE REVIEW

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## 1.1 INTRODUCTION

Access to 12 years of education for all children, and voluntary family planning for all women and girls, are basic human rights and key tenets in the achievement of gender equity. While much progress has been made in both areas over the last several decades, significant gaps still exist in ensuring access to health and education in many parts of the world today.

Universal education and access to voluntary family planning are included as solutions in Project Drawdown because advancing those rights has an effect on fertility rates and population changes over time. Population size and growth are key drivers of demand for food, transportation, electricity, and other resources, all of which contribute to the overall levels of carbon and greenhouse (GHG) emissions.

### **Health and Education Sector solutions:**

- *Universal education for girls and boys* – providing equal access to 12 years of quality education for all children currently being denied access. The opportunity to complete of schooling can lead to improved livelihoods, delayed onset of marriage, delayed childbearing, and smaller, well-spaced families with fewer children.
- *Voluntary family planning* – scaling-up voluntary family planning efforts, including access to affordable, quality contraception and SRHR services, especially in countries where unmet need for contraception is high or demand is low, leading to a decline in unintended or unwanted pregnancies, total fertility rates, and unchecked population growth.

The next section of this technical report describes the current literature pertaining to the factors and barriers that affect access to education and health (particularly SRHR services and family planning), as well as how these are interlinked and how they impact fertility trends, population shifts and ultimately, the climate.

## 1.2 DETERMINANTS OF FERTILITY

The Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MEASURE DHS) project, funded by USAID, collects and disseminates nationally representative data on indicators such as fertility, maternal and child health, family planning, HIV/AIDS and gender for over 250 countries via population-based surveys (Demographic and Health Surveys, 2007). The total fertility rate (TFR) of a country or region is defined by MEASURE DHS to be “the number of children who would be born per woman if she were to pass through the childbearing years bearing children according to a current schedule of age-specific fertility rates” (MEASURE DHS, n.d.).

Typically, drivers of fertility are categorized into two classifications: proximate determinants and socioeconomic determinants of fertility behavior. In 1978 John Bongaarts proposed a framework for assessing the proximate determinants of fertility, enumerating 8 determinants: percentage of women in sexual union; frequency of sexual intercourse; postpartum abstinence; lactational amenorrhea; contraceptive use; induced abortion; spontaneous intrauterine mortality; natural sterility and pathological sterility (Bongaarts, 1978). The Demographic and Health Surveys (DHS) Program, which provides the most widely used demographic and health information on developing countries, identifies the following indicators as proximate determinants of fertility: current marital status; sexual relationships of non-married women; number of co-wives (women) / number of wives (men); age at first marriage; age at first sexual intercourse; recent sexual activity; median and mean durations for postpartum amenorrhea (abstinence and insusceptibility)(Demographic and Health Surveys, 2007).

With regard to socioeconomic determinants of fertility behavior, several analyses of historical fertility declines reveal the importance of cultural factors in determining the responsiveness of fertility levels to socioeconomic change (T. Anderson & Kohler, 2015). Attitudes, beliefs, knowledge and practices related to reproduction vary significantly by socioeconomic status, both within and across communities and countries. Religious groups vary in their emphasis on the value of children and their prescriptions regarding family size and contraception (McQuillan, 2004). Ethnic groups differ in their values concerning economic and social advancement, which can influence age at marriage and desired family size (Sorokowski et al., 2017). Gender roles and expectations vary by culture and have implications for employment and educational outcomes for both men and women, also significantly impacting family planning decision making (McDonald, 2000). Thus desired family size depends primarily on female and male education, child survival and the value given to children, and the demand for female labor in the labor market, which can be tied to a country's level of development (Subbarao and Raney, 1995).

It is important to acknowledge that fertility behavior is complex and influenced by a number of factors; as a result, the associations between development and fertility decline are not always simple, direct, or clear. As the next sections will demonstrate, fertility can be influenced by factors at the individual, familial and societal level, as well as by cultural and contextual considerations.

### 1.2.1 Female agency and reproduction

The status of women and their level of agency in a society can either facilitate or inhibit their educational and employment opportunities, access to family planning and health services and concomitant fertility decline. High fertility is usually found in countries where poverty is widespread, where women are not paid significant wages, and where the status of a woman is conferred through her ability to bear children (Wickrama & Lorenz, 2009). In these places women and girls are expected to maintain their traditional role of unpaid worker: bearing and

raising children, managing the household, preparing food, gathering fuel and water, and maintaining the family resources (Gammage et al., 2020).

Development interventions that promote greater economic and social autonomy of women are critical for both population and climate consideration (Eastin, 2018). The socioeconomic argument proposes that education, especially of the mother, affects desired family size (DFS) through wage and productivity effects on the opportunity cost of the mother's time. It also improves the chances of child survival, and thus it indirectly affecting demand for children (Subbarao & Raney, 1993). Education promotes awareness of the use of modern methods of contraception effectively and thus helps people achieve their DFS (Liu & Raftery, 2020). Together with family planning interventions that focus on meeting the unmet need for contraception by reducing the financial and social barriers to access, promoting universal education focuses on keeping boys and girls in school, and delaying early marriage and childbirth, particularly for girls (Global Partnership for Education, 2019). Restricted access to family planning information and services and limited educational opportunities impedes a critical opportunity for women's empowerment, and continues to reinforce the gendered expectations and status of women as a child bearer and caretaker.

### 1.2.2 Education and fertility

Historically, the links between educational attainment and changes in fertility have had women and girls as the focal population, because fertility rates are inherently measured based on women's reproductive outcomes. Due to a dearth of research on impact of universal education (for girls and boys) on fertility, this section will mostly focus on women's education and the different ways this affects and influences fertility choices and decisions, while acknowledging that much work is to be done in exploring the role and influence of men's education on fertility trends over time.

Until the mid-1970s, studies focused on the effects of women's schooling on their fertility outcomes, individual education, and individual fertility (Bongaarts et al., 2017). Simple correlations and multiple regressions revealed the relationship to be negative; the longer a woman remained in school the fewer children she was likely to have (Monstad et al., 2008). Between the mid-1970s to mid-1980s research focus shifted to determining the effects of education on what was later understood as proximate determinants of fertility such as marriage rates, contraceptive prevalence rates, and DFS (Bongaarts, 1978). The general takeaway from this body of research is that education does not influence fertility directly but acts through a number of biological and social indicators. The DHS program has been conducting household surveys in developing countries since 1984 and the wealth of data it provides led to the next shift in the research agenda, investigating intergenerational links between education and fertility and the reciprocal influences of women's educational attainment between child welfare, labor force quality, economic inequality, and social stratification (Conger et al., 2010). The results of these studies are mixed and highlight the fact that the relationship between education and fertility is really an array of varying and complex associations (Arokiasamy et al., 2004; Basu, 2002; Psaki et al., 2019).



Recognizing methodological issues such as endogeneity, contextual variation, and heterogeneity, the precise way in which education affects fertility remains up for debate. Education at the individual level is associated with increased employment prospects, the transfer of knowledge about the costs of children, and an increase in social skills enabling better use of health services and information (Kim, 2016; Mensch et al., 2019). Education's impact at the societal level is associated with change in norms surrounding the timing of the initiation of marriage and childbearing, contraceptive use, and desired family size (Götmark & Andersson, 2020; Lawson & Mace, 2010). Regardless of the mechanism, the statistical relationship between fertility and education is generally understood to be negative, explained by causation, heterogeneity, reverse causation, or endogenous association (Götmark & Andersson, 2020; Kim, 2016). While the exact mechanism through which education affects fertility is not clear, especially given that both an individual's education and the education system may play a role, it is clear that the socioeconomic environment is a key factor in educational and fertility choices and outcomes.

Women with more schooling and better education have lower fertility than less educated women for a number of reasons. They marry later; have fewer years of childbearing; have better knowledge of family planning; they have more autonomy to control their childbearing; and recognize the costs of additional children (Psaki et al., 2019). As demonstrated through DHS data, formally educated girls make healthier sexual and reproductive decisions including but not limited to contraceptive use (USAID, 2014). As Campbell et al note, educating girls and women is important for their empowerment, allowing them to better discern information and make informed choices (Campbell et al, 2013). The effects are not limited to formal education as informal education, such as literacy programs and health education efforts can also influence health-related behaviour change (Murphy and Carr, 2007). Overall, an educated woman has the potential for economic independence, is more self-reliant, and less susceptible to early marriage. Her values may become more closely aligned with modern institutions such as health care systems, and education may improve her confidence and skill in accessing them (Psaki et al., 2019).

Generally, education tends to be associated with later age at marriage and increased contraceptive use, but these individual behavioral choices are not possible unless accompanied with an enabling social, political, cultural, and economic environment (Mutumba, Wekesa, and Stephenson 2018). The presence or absence of mass education for girls and women (and the resulting economic and social benefits); the quality and accessibility of family planning programs; and gainful employment opportunities for women, are all linked to fertility outcomes and cannot be overlooked when considering the effects of education (Walter et al., 2021).

Research tells us that women with just a few years of primary schooling are unlikely to experience fertility decline as a direct result of that education; however, fertility declines often occur among women with some secondary education (Mensch et al., 2019; Psaki et al., 2019). Furthermore, the less developed the country, the more years of education are required to affect fertility and related indicators, which support the argument about the role of contextual factors in fertility change (T. Anderson & Kohler, 2015; Bonneuil, 1990; Kim, 2016).

### 1.2.3 Access to voluntary family planning services

In most regions around the world and for most of human history, large families (7 to 8 live births) have been the default. Global population remained relatively stable since mortality rates were very high and only about two children per couple survived long enough to procreate (Bongaarts, 2009). Although birth control can be traced all the way back to 1500 BC, it wasn't until relatively recently that men and women had access to reliable contraceptive methods that could effectively prevent intercourse from resulting in pregnancy (Benagiano et al., 2007). This lack of reliable contraception and modern medicine's success in increasing life spans, led to a population explosion in the 19th century. However, in much of the high and middle income countries family planning use has increased, birth rates have fallen, and population growth has slowed (Bongaarts, 2009). Despite this slowed population growth in developed countries, birth rates remain high in much of the developing world, particularly in sub-Saharan Africa (SSA). To slow this growth, access to and uptake of family planning, reproductive health services and information must be improved.

Voluntary family planning, through the use of contraceptive methods, is the practice of controlling the timing, spacing and number of children in a family to limit the number of unintended or unwanted pregnancies (World Health Organization, 2020). Contraceptive methods are divided into two main categories: traditional and modern methods, which are then further categorized into short-term and long-term methods. Modern methods include barrier, hormonal, surgical and other such bio-medical approaches. Natural methods such as lactational amenorrhea method (LAM, i.e. fertility suppression due to breastfeeding), periodic abstinence, withdrawal and fertility awareness are typically thought of as traditional methods. Short-term methods include the pill, condoms and the vaginal ring; long-term reversible methods include injectables, implants, intrauterine devices (IUDs); and permanent methods include male and female sterilization (World Health Organization, 2020).

Research shows that when individuals have a choice, they more often choose to have smaller families, meaning that barriers to family planning use extend beyond individual decision making (Campbell et al, 2013). Decisions about sex and reproduction are made within an economic, social, cultural, political and religious context (Sohn, 2020). Numerous barriers stand in the way of successful use of family planning; yet countries like Iran, Bangladesh, and Ethiopia demonstrate that with enough political will and central planning, it is possible to increase contraceptive prevalence rates (CPR) and reduce fertility rates over a short period of time (Karamouzian et al., 2014; Olson & Piller, 2013; Schuler et al., 1995). Efforts to increase the global contraceptive prevalence rates and decrease fertility rates face limitations including but not limited to: restrictive policies; poor quality of and access to FP services, particularly in rural areas; a shortage of skilled health providers; inadequate supply of commodities; norms discouraging contraceptive use; high desired family size; and lack of knowledge and persistent misconceptions about modern FP methods (Bertrand et al., 1995; Korachais et al., 2016; Solo & Festin, 2019). These highlight both the supply and demand, as well as behavioral, social, economic and systemic constraints that must be improved for the increased adoption of FP. Concerted efforts and commitment on the part of national

governments, international donors, NGOs and the private sector are also needed to ensure adequate financing of family planning services (Ali & Bellows, 2018).

### 1.3 CURRENT STATE OF FAMILY PLANNING

As of 2019, an estimated 1.1 billion women had a need for contraception; 922 million of these women had these needs met and were using a contraceptive method (United Nations, 2019). According to the latest figures from the Guttmacher Institute, an estimated 705 million women in low- and middle- income countries (LMICs) used modern contraceptive methods in 2019, averting approximately 376 million unintended pregnancies (Guttmacher Institute, 2020). As a result of these efforts, the numbers of other adverse maternal outcomes that were prevented were as follows:

- 256 million abortions, of which 100 million would have been unsafe
- 79 million unplanned births
- 39 million miscarriages
- 2 million stillbirths

With reference to specific contraceptive methods, female sterilization remains the most commonly used female contraceptive method (Table 1), used by 11.5% of women globally. Male condoms (10%), implants (10%), intrauterine devices (8.4%) and the pill (8%) are the next most commonly used modern methods, though significant regional differences exist in modern contraceptive access, uptake and preference.

Unmet need for contraception, defined by WHO as “the percentage of women of reproductive age who are fecund and sexually active but are not using any method of contraception, and report not wanting any more children or wanting to delay the next child” stood at 11.3%, totaling 218 million women globally (Guttmacher Institute, 2020). While this is a decrease from 255 million women in 2014, these figures indicate a significant gap in provision, access and uptake of contraceptive services, which could have significant implications in terms of unintended or unwanted pregnancies, unsafe abortions, maternal morbidity and mortality.

Table 1: Current contraceptive use among women aged 15-49 years

Region	Estimated prevalence of contraceptive use among women of reproductive age (15-49 years), 2019 (%)											Unmet need
	Any Method	Sterilization F	M	Pill	Injectable	Implant	IUD	Male condom	Rhythm	Withdrawal	Other methods	
World	48.5	11.5	0.9	8.0	1.2	10.0	8.4	10.0	1.5	2.5	0.8	11.3
Developed Regions	57.0	5.7	2.4	16.5	1.0	1.1	7.2	16.3	1.5	4.1	1.4	8.5
Less developed regions	47.0	12.5	0.6	6.5	4.4	1.2	8.6	8.9	1.5	2.2	0.7	11.7
Less developed regions, excluding least developed countries	50.1	14.5	0.6	6.2	3.4	0.9	10.1	10.0	1.4	2.4	0.6	
Less developed regions, excluding China	41.0	12.1	0.5	7.6	5.6	1.5	3.9	5.0	1.7	2.6	0.6	
Least Developed Countries	30.9	2.1	0.4	7.7	9.6	2.9	0.8	3.2	2.0	1.2	1.0	20.6
Land-locked developing countries (LLDC)	31.6	2.1	0.3	4.3	9.4	3.9	5.3	3.0	0.9	1.6	0.8	
Small island developing states (SIDS)	43.1	11.9	0.3	7.9	6.3	1.0	5.0	7.2	1.5	1.3	0.9	
High-income countries	56.6	6.1	3.0	17.2	1.8	1.2	6.5	14.8	1.5	3.1	1.5	9.1
Middle-income countries	49.6	13.8	0.6	6.7	3.7	0.9	9.4	9.9	1.5	2.5	0.6	10.2
Upper middle income countries	61.0	12.6	1.0	7.3	2.4	0.6	16.3	16.6	1.2	2.4	0.8	
Lower middle income countries	40.1	14.8	0.2	6.3	4.8	1.2	3.6	4.4	1.8	2.7	0.5	
Low income countries	28.0	1.7	0.3	3.8	8.7	3.7	3.0	2.9	1.7	1.2	1.2	22.6
Africa	29.4	1.0	0.0	5.8	8.4	3.7	2.6	3.8	1.8	1.0	1.4	20.5
Asia	50.3	14.9	0.6	5.3	2.8	0.5	10.7	10.9	1.5	2.7	0.5	9.8
Europe	56.1	3.0	1.7	19.1	0.5	0.4	8.1	16.4	1.5	4.2	1.2	8.5
Latin America & Caribbean	58.0	16.0	1.3	14.9	6.8	1.5	4.6	8.8	1.6	1.5	0.9	19.4
Northern America	62.4	12.7	4.3	15.1	2.2	2.4	7.6	11.0	1.3	4.0	1.7	5.9
Oceania	49.2	4.9	5.8	16.9	2.9	3.1	3.4	9.3	1.0	1.1	1.0	14.6

The Guttmacher Institute estimates that a package of care that would meet all women's sexual and reproductive health needs in terms modern contraception, pregnancy-related and newborn care, and treatment for STIs would cost US\$ 68.8 billion annually in 2019, which is approximately US\$10.60 per capita per year (Guttmacher Institute, 2020). This is an increase of US\$ 31 billion (83%) over current annual costs, which amounts to about US\$4.80 per capita per year (Table 2). Southern Asian and SSA account for more than 75% (US\$24 billion) of the total increase, and low-income countries mostly in SSA require the largest increase in resources—from US\$3.40 to US\$15.80 per capita annually—as unmet need in these countries are the highest and the health systems, infrastructure and personnel supporting these services require the most expansion and improvement (Guttmacher Institute, 2020). We undertook a preliminary costing analysis based on projected changes in the numbers of women of reproductive age using any contraceptive method across the different Sustainable Development Goal (SDG) regions between 2015 and 2060, together with estimated costs of current FP service provision and costs to meet all FP needs of all women. The estimated costs for meeting the FP needs for women across time are shown below in Table 3 below.

Table 2: Estimated annual costs of current FP uptake among women aged 15-49 years

SDG regions	Costs per year for current FP uptake (thousand US\$)			
	2015	2020	2050	2060
Sub-Saharan Africa	604,692	771,036	1,987,442	2,388,016
Western Asia and Northern Africa	776,943	860,882	1,337,008	1,496,268
Central Asia and Southern Asia	1,179,204	1,306,479	1,996,531	2,227,987
Eastern Asia and Southeastern Asia	2,859,972	2,746,976	2,159,085	1,961,456
Latin America and the Caribbean	2,024,365	2,140,206	2,665,867	2,844,873
Northern America and Europe	2,255,584	2,228,709	2,086,181	2,038,086
Oceania	49,584	52,249	69,036	74,629
<b>World (Total cost)</b>	<b>9,750,345</b>	<b>10,106,537</b>	<b>12,301,149</b>	<b>13,031,314</b>

Table 3: Estimated annual costs to meet all FP needs for all women aged 15-49 years

SDG regions	Costs per year to meet all FP needs (thousand US\$)			
	2015	2020	2050	2060
Sub-Saharan Africa	1,806,619	2,303,597	5,937,812	7,134,594
Western Asia and Northern Africa	823,747	912,743	1,417,551	1,586,404
Central Asia and Southern Asia	1,403,433	1,554,910	2,376,177	2,651,645
Eastern Asia and Southeastern Asia	3,265,017	3,136,018	2,464,867	2,239,248
Latin America and the Caribbean	2,167,454	2,291,482	2,854,299	3,045,958
Northern America and Europe	2,187,463	2,161,399	2,023,175	1,976,534
Oceania	57,059	60,126	79,444	85,880
<b>World (Total cost)</b>	<b>11,710,792</b>	<b>12,420,276</b>	<b>17,153,324</b>	<b>18,720,262</b>

### 1.3.1 A rights-based approach to family planning

Two landmark, integral events that built the foundation for the recognition of women's reproductive rights were the International Conference on Population and Development in Cairo, Egypt 1994, and the Fourth World Conference on Women in Beijing, China in 1995. Both conferences brought together representatives from governments, nongovernmental organizations, international agencies, and civil society to reach international consensus on the importance of a rights-based approach to addressing sexual and reproductive health, women's participation and empowerment and ending all forms of discrimination against women (Roberts, 1996; Shaw, 2007). Since then, much progress has been made in advancing women's reproductive health rights, and a rights-based approach has been adopted in family planning programs and policies across the world, in recognizing that it is the rights of individuals and couples to decide voluntarily, freely and responsibly about the number of children to have and when to have them, and to be able to access methods and information to achieve this (Hardee et al., 2014).

In addition to its potential impact on atmospheric GHG concentrations, the social, economic and health benefits of family planning are broad. Access to reproductive health services allows for couples to control their reproductive futures thereby allowing them to participate more meaningfully in social and economic life. Family planning is recognized by the United Nations as a human right and a development priority, because contraceptive uptake, whether through modern or traditional means, is an important determinant of maternal and child welfare (United Nations Department of Economic and Social Affairs, Population Division, 2020). Research from the Guttmacher institute reveals that access to modern contraception and safe abortion is a major factor in women pursuing higher education, joining the workforce and delaying marriage (Singh et. al, 2014). Education allows women more freedom to make informed decisions about if and when they want to have children, and other important life matters.

### 1.3.2 Family planning and the SDGs

In addition to advancing human rights, access to voluntary family planning is key to achieving progress in health and sustainable development for women, families and society (Starbird et al., 2016), and is recognized as an integral part of the current SDGs. SDG #3 addresses the health and wellbeing of populations, while SGD#5 focuses on gender equality. In terms of women's health specifically, target 3.1 is to "reduce the global maternal mortality ratio to less than 70 per 100 000 live births by 2030", while targets 3.7 and 5.6 are to "ensure universal access to sexual and reproductive health care services, including family planning, by 2030", and to "ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action", respectively. Without universal access to family planning and reproductive health, the impact other efforts and initiatives to address the 5 major themes of the SDGs- People, Planet, Prosperity, Peace, and

Partnership- will be less effective, will cost more, and will take a longer time to achieve (Frischmann et al., 2020).

## 1.4 CURRENT STATE OF EDUCATION FOR GIRLS AND BOYS

### 1.4.1 Global levels of primary and secondary education

Enabling and improving universal education requires increasing the number of girls and boys enrolled in and completing both primary and secondary school; improving their participation while in school; improving the quality of education received; and enhancing the ways in which education empowers them (UNESCO, 2020). The ability to achieve all these improvements is affected by processes within and beyond schools, requiring interventions addressing policy, allocation of resources, funding, infrastructure, systems strengthening, and norms (UNESCO, 2016).

Despite substantial progress in increasing school enrolment and completion rates in the last decade, estimates for 2020 from the Global Education Monitoring Report by UNESCO indicate that an estimated 258 million children and adolescents are not in school; at the different levels of education, these numbers amount to 59 million primary school-aged children (1 in 12), 61 million lower secondary school-aged adolescents (1 in 6) and 138 million upper secondary school-age youth (1 in 3) (UNESCO, 2020). In terms of regions, slightly over 50% of out-of-school children and adolescents were in SSA in 2018, overtaking numbers in Southern and Central Asia for the first time. Globally, school completion rates stood at 85% for primary, 73% for lower secondary and 49% for upper secondary education, with the gap between enrolment and completion rates in LMICs having shrunk from 35% to 26% between 2008 and 2018.

Despite the discernible benefits of investment in education, universal completion of pre-primary, primary, and secondary school is not easily achieved. The increasing size of school-age cohorts in low-income countries, and rising costs per student make public financing of universal education difficult. UNESCO (2020) estimates that achieving universal education by 2030 will cost US\$340 billion per year, revealing an annual financing gap of US\$39 billion. More teachers and more facilities are needed to accommodate the projected growth in enrolment; as a result, low-income countries will need to increase average expenditure per primary school student from US\$70 to US\$197 by 2030 (Education For All: Global Monitoring Report, 2015). Aid efforts for education, which is expected to stagnate for the next few years, has fallen short of the required 42% of total costs that still need to be covered in low-income countries. A growing number of multilateral and bilateral donors are focusing financial assistance on secondary and post-secondary education, with the exception of the United States who directs roughly 80% of its aid to primary education. Currently, the majority (70%) of funding provided to low-income countries for post-secondary education is in the form of scholarships to study in donor countries rather than being allocated to the strengthening of higher education system.

A preliminary projection for the cost of achieving universal education in LMICs was computed based on 2015 UNESCO cost estimates for different levels of schooling (UNESCO, 2015), shown in table 5 below.

#### 1.4.2 Education and the SDGs

Goal 4 of the SDGs emphasizes equitable and quality education as a universal human right, with targets 4.1-4.7 and 4a-c focusing on specific aims for different educational sectors and subpopulations. For instance, target 4.7 advocates that “by 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture’s contribution to sustainable development (UN, 2015). Goal 4 also recognizes the critical role that education plays in the achievement of all the other SDGs (FHI360 2016); in enabling socioeconomic progress and helping to overcome poverty, universal education for girls and boys is an important tool to ensure improved health and nutrition, gender equality, and informed choices around economic empowerment, responsible consumption and sustainable living, all of which contribute to an improved quality of life (Frischmann et al., 2020).



Table 4: Rates of enrolment and completion of primary, lower secondary and upper secondary schooling for both sexes in 2019

	Enrolment (n)			School completion (%)		
	Primary	Lower secondary	Upper secondary	Primary	Lower secondary	Upper secondary
World	739,447,189	337,640,718	263,625,826	82	69	44
Least Developed Countries	159,644,461	42,669,927	23,180,424	58	36	22
Land-locked developing countries (LLDC)	77,332,592	24,093,638	10,950,159	-	-	-
Small island developing states (SIDS)	8,627,555	2,582,068	2,119,471	-	-	-
High-income countries	79,525,031	46,183,870	45,011,597	-	-	-
Middle-income countries	552,143,029	267,256,233	205,781,164	-	-	-
Upper middle income countries	240,286,221	126,039,633	96,141,795	-	-	-
Lower middle income countries	311,856,808	141,216,600	109,639,369	-	-	-
Low income countries	107,774,923	-	-	-	-	-
Africa (Sub Saharan)	174,282,479	39,856,135*	21,162,314*	62	42	30
Asia	398,503,478	197,738,903	165,847,743	South Asia: 88	South Asia: 73	South Asia: 41
Europe	40,600,895	32,254,327	26,158,946	-	-	-
Latin America & Caribbean	64,344,966	37,999,425	26,212,296	94	77	48
Northern America	27,783,112	14,159,194	13,604,216	-	-	-
Oceania	4,581,464	2,065,150	1,639,810	East Asia and Pacific: 96	East Asia and Pacific: 83	East Asia and Pacific: 58
Eastern Europe and Central Asia	-	-	-	-	95	64
Middle East and North Africa	-	-	-	-	67	53

\* Rates for 2018- Data not available

### 1.4.3 The social costs of not educating girls

While Project Drawdown's education solution focuses on access to universal education for both boys *and girls*, the reality is that in many regions and contexts today, equitable access in terms of enrolment and completion of schooling is not a level playing field between boys and girls. In 2018, approximately 129.2 million girls were out of school; 32.3 million girls of primary school age, 29.9 million girls of lower secondary school age, and 67 million girls of upper secondary school age (Global Partnership for Education, 2019).

In a World Bank report titled 'Missed Opportunities: The High cost of not educating girls', the disparities that still exist in many countries between girls and boys receiving a quality education, particularly at the secondary and tertiary levels, is well documented (Wodon et al. 2018). Low educational attainment, particularly for girls, has far reaching negative consequences for girls themselves as well as their families and children, communities and societies. Girls who drop out of school early are more likely to marry and bear children earlier (often before they are physically and emotionally ready), which in turn can affect their health as well as the health of their children (McCleary-Sills et al., 2015). Girls who are unable to complete their education also often lack agency and decision-making autonomy in the household, making them more vulnerable to intimate partner violence, unplanned pregnancies and an inability to access or afford healthcare (Delprato et al., 2017). With lower economic opportunities and a likelihood of higher fertility in their lifetime, these girls often find themselves in situations of poverty and malnourishment, unequipped to care and provide for more children than they desired to have (Parsons et al., 2015).

The World Bank report estimates that barriers to completing 12 years of education and limited educational opportunities for girls cost countries between US\$15-30 trillion in lost lifetime productivity, human capital wealth and earnings. The report also highlights 6 specific domains that are most impacted by the low educational attainment of girls, particular to secondary education are:

- **Economic opportunities and standard of living:** It is estimated that women with primary education earn between 14-19% more than women with no education, while women with a secondary education earn twice as much, and those with a tertiary education or higher earn three times as much as women with no education.
- **Child marriage and early childbearing:** Every additional year of secondary education is associated approximately 6% lower risk of marrying early and having a child before the age of 18. Hence, if universal secondary education was achieved, child marriage could potentially be eliminated, and the prevalence of early childbearing drastically reduced.
- **Fertility and population growth:** Secondary education can lead to an increase in contraceptive use, and could reduce total fertility by up to a third in some low and middle income countries. If girls were better educated, and if child marriage were to be drastically reduced, unintended pregnancies could be avoided and unchecked population growth would decrease.

#### 1.4.4 Climate education and green skills

A report by Christina Kwauk titled “Roadblocks to quality education in a time of climate change” speaks of the strong role that education plays in both climate adaptation and mitigation (Kwauk, 2020). Higher education levels correlate with increased adaptive capacity in climate-related disasters, especially for women (Didham & Ofei-Manu, 2020), and increase the skills and knowledge necessary for resilience and mitigation against the impacts of climate events (United Nations, 2015). Research has shown a strong and positive correlation between educational achievement, skills and behaviors that contribute positively towards the environment. The ripple effects of education extend beyond just individuals by fostering greater awareness and conscious decisions about the environment among families and communities, thereby empowering them to reduce their vulnerabilities to climate-related events that occur due to global warming (A. Anderson, 2010). A recent study based on the “Powers of 10 framework,” provides a useful model for envisioning effective climate action through education. The model suggests that in order to reach the highest reduction of GHG emissions, both in terms of the number of climate actions and strategies involved as well as the economic benefits of those actions, groups of between 10,000 and 100,000 people— at the scale of communities, groups of communities, and cities (Bhowmik et al., 2020) need to be effectively engaged. The formal education system is one such avenue that creates the infrastructure of a tiered system for climate action at several levels and scales, beginning at the individual school level and extending to the district/state, country, regional, and global levels.

Educating girls could have an even more profound effect; emerging research in LMICs suggest that a gender-transformative education could ensure that girls are aware of their rights and are able to develop green skills and leadership attributes that are critical to innovation in industries in the green sector, and participation in climate-related decision-making (Casey, 2021).

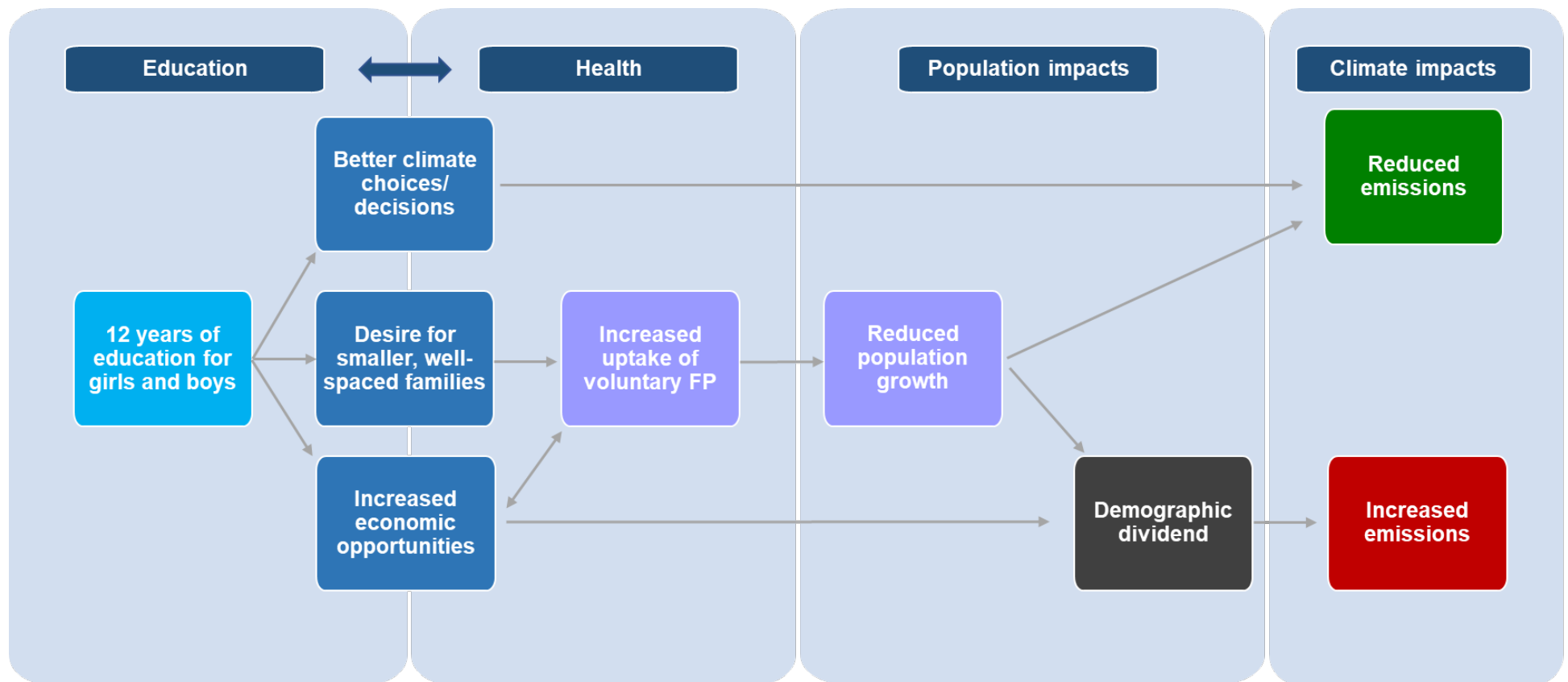
### 1.5 POPULATION DYNAMICS AND CLIMATE CHANGE

In the context of Project Drawdown’s focus on reducing GHG emissions, the links between universal education, improved access to health services, population changes, and resulting climate impacts over time are complex, interconnected, and multi-level, as shown in Figure 1. As described in the preceding sections, there are a multitude of benefits that result from 12 years of education for both girls and boys. Education can influence many aspects of people’s lives, such as how many children and when to have them, where to live, how to manage their resources and care for their family. Education also offers more economic opportunities and possibilities to earn a living and support oneself and one’s family. Finally, education can impact the ways in which people think about and interact with the planet, as well the choices they make in relation to the climate, potentially leading to lowered emissions over time.

The intersecting benefits of ensuring access to universal education and quality SRHR services can result in a reduction in GHG emissions through a few pathways. Increased economic

opportunities, often coupled with urban migration, could lead to couples choosing to have smaller families, facilitated by the use of family planning (Starbird et al., 2016). The impact of family planning on emissions reductions therefore results from the effect of modern contraception on slowing rapid, unchecked population growth from reducing the number of unwanted or unintended pregnancies. While recognizing differences in emissions per capita across different regions and contexts and acknowledging that regions of high population growth do not necessarily contribute the highest emissions, it can be assumed that a reduction in the total population of emitters of GHG will result in fewer carbon emissions over time (Dodson et al., 2020).

Reduced population growth, coupled with increased economic opportunities, can also contribute towards a demographic transition from high fertility and mortality to low fertility and mortality, also known as a 'demographic dividend'. The UNFPA defines this as "the economic growth potential that can result from shifts in a population's age structure, mainly when the share of the working-age population (15-64 years) is larger than the non-working-age share (14 and younger, and 65 and older) of the population"(UNFPA, 2016). The impacts of the demographic dividend will be described in greater detail in a later section, but in the context of climate impacts, the transition can often lead to urbanization, coupled with better health, education, economic opportunities and smaller families. This allows for larger investments in children's health and education, more freedom for women to seek employment, and more savings, enabling a better quality of life. Depending on the systems and societies in which this takes place, the increased consumption and production of resources and services to support this transition could lead to an increase in GHG emissions.



3

Figure 1: Links between education, health, population growth and climate impacts

## 1.6 PATHWAYS TO ADOPTION

### 1.6.1 Barriers to family planning uptake

Globally, an estimated 218 million women have an unmet need for family planning (Guttmacher Institute, 2020). There are a number of reasons why such unmet need for safe and effective family planning methods still exist. Reasons vary by region, country and even within communities. In many areas, especially rural and remote, there remain significant supply-side barriers such as cost, product availability, distance to services, and provider bias (Ali & Bellows, 2018). Where commodities are available, persistent demand-side barriers exist – especially psychosocial factors limiting uptake among conservative, isolated, and marginalized populations such as youth, unmarried women, ethnic minorities, and some religious groups (Ensor & Cooper, 2004; Mwaikambo et al., 2011).

Women's agency and empowerment is a vital component of family planning. Women, particularly in patriarchal societies often lack the autonomy to make their own sexual and reproductive choices (Patrikar et al., 2014). Husbands, mothers-in-law and other community and family members can have more authority in a woman's life than she does. Ensuring all women have decision-making power over their fertility would overcome a major and pervasive impediment to expanding FP. Strategies to address this could include increasing/improving male engagement as part of a couple in discussions and decisions around reproductive health, particularly around family size and child spacing (Hardee et al., 2017).

Concerns and misconceptions about the possible side effects of contraceptive methods can be a barrier to FP uptake in many contexts. Fears of infertility, congenital abnormalities and excessive bleeding are often associated with contraceptive use, and efforts to dispel such beliefs and educate women about the proper management of possible side effects should be an essential component of FP counselling (Population Reference Bureau, 2019).

In many countries, the health workforce does not have the immediate capacity (whether technical, operational or personnel) to meet demand for services. One way to overcome this challenge is by task shifting, or utilizing community health workers to deliver services (Scott et al., 2015). Provider bias among health providers poses a major threat to ensuring methods choice for individuals. Providers may set arbitrary restrictions on who can access what services and may have negative attitudes toward certain groups, e.g. youth or unmarried women, preventing access to quality services and introducing an additional barrier (Solo & Festin, 2019). Training providers in interpersonal communication and promoting and strengthening respectful client-centered approaches is key.

Weak systems for monitoring and managing contraceptive commodities can limit access, especially in rural and remote settings, therefore, developing commodities procurement, management and distribution systems is critical. A weak or restrictive policy and regulatory environment can make integration and mainstreaming of FP policy challenging (Prata, 2009).

Mobilizing civil society and communities to advocate for the underserved and demand expanded services is critical for shifting attitudes of decision makers.

### 1.6.2 Barriers to education

Committing to universal, inclusive education for all children everywhere in the world, in line with international declarations as part of the UN 2030 Agenda for Sustainable Development of ‘leaving no one behind’, is no easy task (UNESCO, 2020). Emphasized by the stark figures that 258 million children and adolescents are not in school, a plethora of barriers to achieving education exist globally, coupled with more nuanced barriers at the regional, national and societal levels in many country contexts (UNESCO, 2020).

Access to a quality education can often be hampered by financial or geographical constraints. Though public education in many countries is free, parents of low income households may not be able to afford books, uniforms and associated or indirect fees of sending their children to school (Hunt et al., 2008). For families living in poverty, the opportunity cost of children being in school, particularly if and when they are critical to helping the family earn an income can often result in children dropping out of school early or not completing all 12 years of their education. For example, girls are commonly asked to help out with domestic chores or look after their younger siblings, while boys are often tasked with agricultural labour; most of these tasks often go unpaid and take up significant amounts of time, preventing children from attending school regularly or consistently (Guarcello et al., 2005; Morrow & Boyden, 2018). For children living in more rural or remote parts of a country, access to quality schooling could involve travel over long distances (Birdsall et al., 2005; van Maarseveen, 2020); for some families, the costs of boarding school may not be an affordable option.

Students can also be at a disadvantage due to gender, language, and/or ethnicity. Inclusive, educational environments for students of different backgrounds and those with disabilities and/or special needs are imperative in achieving universal education for all, and in ending the systemic discrimination and vulnerabilities that some students face due to their family and life circumstances.

The availability of sufficient trained and qualified teachers and educational resources at all levels of education is another limiting factor in ensuring a quality, universal education. In many contexts, this is affected by a multitude of factors including funding, adequate training and professional development opportunities, appropriate wages, and supportive policies and educational systems that facilitate learning and teaching, to name a few (Birdsall et al., 2005; Brundrett, 2014).

The safety of children going to school can also be a significant concern in some parts of the world. Long and at times dangerous routes to school that children may need to walk due to poor public transport can be associated with an increased risk of exhaustion, traffic accidents, and violence along the way (UNESCO, 2020). Poor infrastructure of schools in terms of inadequate ventilation,

sanitation facilities and access to water can further compound the problem. A lack of facilities for managing menstrual hygiene is often a reason girls do not attend school regularly (Sommer et al., 2016).

### 1.6.3 Other factors that affect health and education

#### 1.6.3.1 Poverty

With the first SDG dedicated entirely to addressing poverty globally, it is no surprise that poverty has far-reaching implications on the health and education sector as well. According to recent estimates from the UN, 10% of the world's population (734 million people) in 2015 lived on less than US\$1.90/day, with the majority living in SSA (UN, n.d.). While this is a decrease from 36% in 1990, a large number of people worldwide continue to live in extreme poverty today, struggling to fulfil basic needs like access to water, sanitation health and education. The COVID-19 pandemic has further exacerbated this situation, with an additional 70 million people being pushed into extreme poverty this year(UN, n.d.).

Almost 60 years ago, P.T. Bauer wrote about 'the vicious circle of poverty'(Bauer, 1965), which unfortunately is still the reality in many parts of the world today. Poverty can be both a cause and consequence of poor health behaviour and outcomes, which in turn hamper educational and economic opportunities or possibilities. Children born into poverty are more likely to remain in poverty, being unable to access quality schooling or often having to drop out of school to help earn money to support their families. Poverty is also closely interlinked with hunger, and families living below the poverty line are often malnourished, unable to earn a living to afford good quality food or regular meals (Hickel, 2016). This in turn can lead to ill health, a lack of productivity and inability to generate income, further propagating the circle of poverty.

Education is an important strategy in enabling people to earn their way out of the poverty trap (Tilak, 2002). The human capital theory posits that education results in increased human capital, which in turn leads to economic growth. In addition, education as a basic need and human right, allows people to make better and more informed choices, leading to the ability to access and fulfil other basic needs and an improved quality of life.

While populations living in more rural or remote areas of a country have a higher likelihood of belonging to the lower income strata, the absolute numbers of this group have reduced over time, while the urban poor, particularly those urban slums are also an important demographic that need to be increasingly recognized and targeted in efforts around poverty reduction and eradication (Sridhar, 2015). With changing migratory trends and increasing urbanization, larger numbers of people are moving towards cities and urban dwellings in an effort to access better education, economic and livelihood opportunities. This is likely to be accompanied by an increase in the proportion of urban poor in many parts of the world.



People living in poverty are also one of the most vulnerable groups that are impacted by global warming and climate-related events (Hallegatte et al., 2018), and climate change, similar to the COVID-19 pandemic, can also result in more people being pushed into poverty. For many low income families affected by natural disasters such as floods, drought or famine, resilience to the shocks and damage caused by such events is low, and recovery is often slow and a constant struggle. Schooling can be affected, livelihoods destroyed and health consequences further exacerbated due to breakdowns in the health system infrastructure and access to services.

#### 1.6.3.2 Gender equity

SDG 5 focuses on the achievement of gender equality and empowerment of women and girls, with specific targets revolving around ending discrimination and violence against women and girls, eliminating harmful practices such as child marriage and female genital mutilation, and ensuring access to sexual and reproductive healthcare, economic resources and participation in leadership and decision-making across political, economic and public spheres (United Nations, 2020). While many wins and much progress has been achieved in this area in the last several decades- in 46 countries today, women occupy more than 30% of the seats in parliament, and in South Asia, the risk of a girl marrying in childhood has decreased by more than 40% since 2000- there remains much left to do. According to the most recent UN estimates for SDG 5:

- 750 million women and girls globally have been married off before the age of 18 and at least 200 million women and girls in 30 countries have undergone FGM.
- Only 52% of women who are married or in a union are freely able make their own decisions about sexual relations, contraceptive use and health care.
- Globally, women make up only 13% of agricultural land holders.
- 19% of women and girls aged 15 to 49, have experienced physical and/or sexual violence by an intimate partner within the last 12 months; yet, 49 countries lack laws protecting women from domestic violence.
- In 18 countries, husbands can legally prevent their wives from working; in 39 countries, daughters and sons do not have equal inheritance rights

Ensuring that women and girls are able to complete 12 years of education, and can access quality healthcare cannot take place without addressing underlying barriers to gender equity (Kennedy et al., 2020). The continued existence and propagation of power imbalances and unequal gender roles, norms and expectations that favor men and discriminate against women, whether it be in the workplace, community or home, continue to impede progress in this area and affect women's and girl's agency, autonomy and access to equal opportunities for education, health and employment (United Nations, 2020). Unequal power relations between men and women also make women more vulnerable to violence, disempowerment and poverty and it is often women and girls who bear the brunt of climate-related disasters, forced migration, maternal and child morbidity, and financial and economic hardship(Lama et al., 2021; United Nations, 2015).

### 1.6.3.3 Urbanization

Globally, the effects of urbanization on climate, as well as population health and education, are variable, multi-level and complex. As places of residence, cities or urban settlements house almost 50% of the population globally. For many, urban migration signifies better prospects in terms of employment, health, education and quality of life, and big cities are often critically contributing hubs to national economies. However, unchecked, rapid urbanization can also result in environmental degradation, poverty and strained or insufficient resources for meeting growing population demands. Common examples of urban health hazards include overcrowding, substandard housing, poor sanitation, contaminated drinking water supplies and air pollution (Moore et al., 2002).

In the context of climate change, urbanization, similar to population growth, is commonly highlighted as a contributing factor to increased greenhouse gas emissions. However, in a paper on the relationships between population growth, urbanization, and climate change, David Satterthwaite posits that it is growth in the number of consumers and in their levels of consumption in a society that drive climate change, rather than absolute rates of urbanization or population growth (Satterthwaite, 2009). While urban migration in some regions may correlate with increased consumption of resources and energy, this is not always the case, and in some regions of the world where population is still growing rapidly, overall emissions remain quite low. The demographic transition, or demographic dividend, which is explained in more detail in the section to follow, is also closely interlinked with improvements in health and education, and can be a contributing factor towards urbanization and increased emissions in some contexts (Dyson, 2011).

### 1.6.3.4 The demographic dividend

The demographic transition, demonstrated through a demographic transition model, refers to the “transition from high birth and death rates to low birth and death rates as a country develops from a pre-industrial to an industrialized economic system” (Bongaarts, 2009). Whether it applies to today’s developing societies remains to be seen. However, there are country-level examples demonstrating that when political will and investment in family planning are high, countries can achieve very rapid declines in fertility. The total fertility rate (TFR) declined from 6 to 3.5 in Iran in just 6 years, and in Thailand in just 8 years; the same decline in the US took nearly 60 years to achieve (Roser, 2014).

It is estimated that 99% of population growth in this century will be attributed to less developed countries (LDCs) (Population Reference Bureau, 2014). Replacement level fertility is roughly 2.1 children per woman for most countries, although varying modestly with mortality rates (United Nations Population Division, 2021). Fertility rates in most middle income and high-income countries are approaching or below replacement level. However, over the last three revisions of the UN population projections, many country-level projections were revised upward, due to

assumptions of national level contraceptive uptake not holding true – and those countries’ subsequent experience of “stalled” fertility decline (May and Guengant, 2013). The UN has long-held the assumption that all countries of the world are assumed to converge to replacement level fertility and to the same low level of mortality; therefore, the UN Population Division 2012 revisions treat stalled fertility decline as a “temporary phenomenon” – although there is no reason to believe that fertility stalls could not persist where political will and/ or investment is low (United Nations, 2012).

## 1.7 ADVANTAGES OF IMPROVING HEALTH AND EDUCATION

Access to both quality education and healthcare are fundamental human rights. The societal benefits that arise from ensuring equitable access are staggering, and have far reaching implications many domains; poverty alleviation, improved wellbeing and quality of life, women’s empowerment, gender equity, and increased resilience and adaptability in the face of climate-related events, to name a few.

Both financial and human capital investments in family planning are critical for saving lives and improving health among women and children. Global health strategies have long recognized the benefits of family planning. Notably, numerous studies have found a causal link between closely spaced pregnancies and three key birth outcomes: low birth weight, preterm birth and small size for gestational age (Bener et al., 2012). Literature also highlights the association between unintended pregnancies and delayed prenatal care, as women are less likely to realize that they are pregnant in their first trimester if they were not intending to get pregnant (Cheng et al., 2009). Additionally, in countries where abortion is restricted, contraceptive use can lead to fewer unsafe or illegal abortions, and associated maternal morbidity and mortality (Chescheir, 2017).

Based on figures in the latest report in the ‘Adding it Up’ series from the Guttmacher Institute, if all 218 million women in LMICs with a current unmet need for modern contraception were able to meet their contraceptive needs, unintended pregnancies would drop from 111 million to 35 million per year, resulting in:

- 21 million fewer unplanned births each year
- 46 million fewer abortions, of which 26 million would be unsafe
- 8 million fewer miscarriages
- 0.7 million fewer stillbirths
- 70,000 fewer maternal deaths (23% decline from current numbers)

Meeting the unmet need for family planning and preventing unintended pregnancies is one of the most cost- effective ways of slowing global warming (Starbird et al., 2016). In his cost/benefit analysis of investing in family planning as a strategy to reduce future carbon emissions, Thomas Wire found that each US\$7 spent on basic family planning would reduce CO<sub>2</sub> emissions by more

than one ton. In short, family planning provides a useful “stabilization wedge”, or complementary action to reduce GHG (Potts and Marsh, 2010).

The other rights-based solution that directly and effectively reduces unchecked population growth is educating children and keeping them in school longer, which has a number of impacts on reproductive behavior. For example, studies show that in high fertility countries, increasing the age of girls’ childbearing by 5 years would reduce future population growth by 15-20% (Bruce and Bongaarts, 2009). An indirect reduction in population growth is likely explained by education-related improvements in health seeking behavior and improved partner negotiation regarding family size and contraception. Although the immediate health benefits and climate change mitigation potential are enough to justify investment in FP, the payoffs include myriad social benefits. Increases and improvements in women’s education and earnings, children’s schooling, household savings and assets, GDP growth and reductions in poverty have all been associated with family planning (Singh et. al, 2014).

Increasing efforts around education could also have a cascade of benefits in terms of planetary health. It is estimated that if the annual financing gap of US\$39 billion over 2015–30 for reaching universal pre-primary, primary and secondary education of good quality in LMICs was closed, a reduction of 51.48 GTs of emissions by 2050 could be achieved, deemed an ‘incalculable’ return on investment (UNESCO, 2020). As discussed in the previous section, investments in climate education, green skills and climate leadership opportunities among the current and upcoming generations could have significant impact on the ways in which people and societies think about and approach climate change, and the decisions and choices they make in their interactions with the planet.

## 2 METHODOLOGY

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### 2.1 INTRODUCTION

Population projections for the years 2015 to 2060 are an important component for determining estimates of future market sizes for both conventional technologies and Drawdown solutions. Population projections are based on the United Nations (UN) Population Prospects which are released by the Population Division of the Department of Economic and Social Affairs (DESA) every 2-3 years. The UN population projections use three key inputs to determine population growth over time- fertility, mortality and migration. Using trajectories of these parameters and assumptions about how they interact, the UN Population Prospects generates several variants of population projections, including the High, Medium, Constant and Low Variants.

Each Drawdown solution estimates growth, demand and impact from external sources that typically use the UN Medium Population Variant. The population numbers are a key determinant of estimating the current and future Total Addressable Market (TAM) of global functional demand. TAM data for most Drawdown solutions are based on sectors related to energy consumption, building space, mobility, freight, and food demand and waste estimations, which are, in part, functions of global population size and economic conditions. Sources used to determine market size and adoption cases in the Drawdown solution analyses have used the UN medium variant population projections as a baseline for estimation. By evaluating the potential difference in market size of sectors between the high and medium variant population projections, an estimate of associated emissions related to the enlarged sectors is generated.

To model the impact of education and family planning as a solution, we calculate the per capita functional market demand according to a blend of the UN medium and low variants projections. Taken together, we assume that these projections estimate future decline in fertility levels due, in part, to effective uptake of family planning in high fertility countries, and is considered Plausible/Ambitious (REF 2) population scenario. All other things being equal, we then apply the per capita demand to generate a REF 1 population scenario representing a high population projection based on little to no further investment in family planning and education. The REF 1 population scenario is based a combination of the UN high and constant variants (see Table 6). This gives us an estimation of the increased demand required to meet the expected needs of the higher population scenario across all models. Emission results associated with this increased demand are aggregated to produce cumulative emissions impacts by sector.

In January 2021, the Drawdown Population Model was updated with the most recent 2019 UN Population Estimates. In the 2019 revision, the figures from 1950 through the period from mid-2015 to mid-2020 are treated as estimates, and thus the projections for each country or area are made starting mid-2020 and extend until the year 2100.

## 2.2 UN METHODOLOGY FOR FERTILITY PROJECTIONS

In projecting future levels of fertility and mortality, probabilistic methods were used to reflect the uncertainty of the projections based on the historical variability of changes in each variable. The method takes into account the past experience of each country, while also reflecting uncertainty about future changes based on the past experience of other countries under similar conditions (United Nations Population Division, 2021).

In order to project the future fertility decline rate of high and medium fertility countries, the UN uses the historical trends within the country. Wherever data is not available or insufficient they use the world's experience of countries which have undergone the fertility transition to estimate the decline rates (World Population Prospects 2019). Thus, by using a combination of country level and world experience of fertility decline rates, the UN publishes country specific projections of fertility changes over time. All country level projections are then aggregated to represent different variants of world population, based on different assumptions around fertility, mortality and migration. Thus, the world population projections are informed by country level fertility projections.

The UN regularly revises its estimates on fertility based on the emerging data and trends on fertility decline coming from all countries. The 2019 revision mentions that “the world's population continues to grow, albeit at a slower pace than at any time since 1950, owing to reduced levels of fertility. From an estimated 7.7 billion people worldwide in 2019, the medium-variant projection indicates that the global population could grow to around 8.5 billion in 2030, 9.7 billion in 2050, and 10.9 billion in 2100. With a projected addition of over one billion people, countries of SSA could account for more than half of the growth of the world's population between 2019 and 2050, and the region's population is projected to continue growing through the end of the century. By contrast, populations in Eastern and South- Eastern Asia, Central and Southern Asia, Latin America and the Caribbean, and Europe and Northern America are projected to reach peak population size and to begin to decline before the end of this century” (World Population Prospects 2019).

### ***Medium- fertility assumption***

The medium-variant projection corresponds to the median of several thousand distinct trajectories of each demographic component derived using the probabilistic model of the variability in changes over time. The method takes into account the past experience of each country, while also reflecting uncertainty about future changes based on the past experience of other countries under similar conditions.

In the updated 2019 UN medium-variant projection, global fertility falls from just under 2.5 births per woman in 2019 to around 2.2 in 2050 and further to 1.9 in 2100. Underlying such projections for the world are implicit assumptions about ongoing progress in social and economic development, which will influence future fertility levels (United Nations Population Division, 2019).. Specifically, the medium variant assumes that fertility rates will continue to decline in current high-fertility countries and will increase slightly in countries where women on average are now having well under two live births in a lifetime

***High-fertility assumption:***

Under the high variant, fertility is projected to remain 0.5 children above the fertility in the medium variant over most of the projection period. By 2045-2050, fertility in the high variant is therefore half a child higher than that of the medium variant (United Nations Population Division, 2019). That is, countries reaching a total fertility of 1.85 children per woman in the medium variant have a total fertility of 2.35 children per woman in the high variant at the end of the projection period (United Nations Population Division, 2019).

***Low-fertility assumption:***

Under the low variant, fertility is projected to remain 0.5 children below the fertility in the medium variant over most of the projection period. By 2045-2050, fertility in the low variant is therefore half a child lower than that of the medium variant (United Nations Population Division, 2019). That is, countries reaching a total fertility of 1.85 children per woman in the medium variant have a total fertility of 1.35 children per woman in the low variant at the end of the projection period (United Nations Population Division, 2019).

***Constant-fertility assumption:***

For each country, fertility remains constant at the level estimated for the previous five-year period (2010-2015 for the 2015 population projections).

***Instant-replacement-fertility assumption:***

For each country, fertility is set to the level necessary to ensure a net reproduction rate of 1 starting in (2015-2020 for the 2015 population projections). Fertility varies over the rest of the projection period in such a way that the net reproduction rate ensures, over the long-run, the replacement of the population.

***Momentum fertility assumption:***

This variant is new to the 2019 population dataset, and illustrates the impact of age structure on long-term population change. The variant combines elements of three existing variants: the instant-replacement-fertility variant, the constant-mortality variant, and the zero-migration variant (United Nations Population Division, 2019). Under this variant, for each country, fertility is set to the level necessary to ensure a net reproduction rate of 1.0 starting in 2020-2025, while the mortality is kept constant as of 2015-2020 and net international migration is set to zero from 2020-2025 onwards (United Nations Population Division, 2019).

### ***Mortality and International Migration Assumptions***

In contrast with the assumptions made about future fertility trends, only one variant of future mortality trends (median path) is being used for each country as a standard for all three population projections variants (e.g., high, medium and low fertility variants) (World Population Prospects 2019). Thus, the role of mortality in influencing the change in projections under different variants is very limited.

International migration assumes that current levels remain relatively unchanged and continue until 2045-2050. Regarding the movements of refugees, it assumes in general that refugees return to their country of origin within one or two projection periods, i.e., within 5 to 10 years (United Nations Population Division, 2019). The international migration numbers at individual country estimates and projections are revisited and altered so that the sum of all international migration adds up to zero at the global level (World Population Prospects 2019).

#### **2.2.1 Assumptions around the uptake of Family Planning**

The UN Population Projections reflect an implicit assumption that the conditions facilitating fertility decline will persist in the future. The UN report on World fertility and Family Planning 2020 states that “in countries experiencing rapid population growth, the future reductions in fertility depicted in the medium-variant projection of the United Nations seem likely to occur if there is continued progress in all facets of development, including further reductions in child mortality, increased levels of education in particular for women and girls, increased urbanization, women’s empowerment and growing labour force participation, and expanded access to reproductive health-care services including for family planning.” (United Nations Department of Economic and Social Affairs, Population Division, 2020). It should therefore be recognised that the UN Medium Variant is based on the assumption that increased uptake of family planning will result in reduced net reproductive rate (NRR), though whether this occurs for all countries in the future, and the speed and extent to which it may occur, are currently uncertain and impossible



to predict. As John Wilmoth, director of the United Nations Population Division, stated: "The medium-variant projection is thus an expression of what *should be possible* if future patterns of behavioral change in childbearing resemble those of the past, for populations at similar levels of fertility. These future trends, however, are not guaranteed. In fact, in light of recent trends for some high-fertility countries, this middle scenario could require additional substantial efforts to *make it possible*" (Population Reference Bureau, 2013).

Project Drawdown relies on the UN Medium Population variant as the basis of the population emissions model and other solution modelling as it is deemed a reliable and realistic projection of population changes over time (Kaneda et al., 2021), and is widely used by many other organizations for estimations around population growth and fertility trends.

## 2.3 THE PDS POPULATION EMISSIONS MODEL

Project Drawdown's core models were developed to account for adoption pathways of different actions within constrained boundaries. The Population Emissions model evaluates the impact of education and family planning uptake on population numbers and the resulting emissions over time. By combining data from different sectors and clusters on per capita emissions (grouped by IPCC region), the model evaluates the impact of different levels of education and FP uptake on overall emissions.

### 2.3.1 Model structure and terminology

The Population Emissions model is an Excel workbook that contains all of the data necessary to calculate the greenhouse-gas reductions associated with the adoption of health and education, and allows users to change inputs for the different clusters that are impacted by changes in population and see how the overall emissions results are impacted.

Across every solution-specific model, population estimates determine total functional demand of conventional technologies/practices for both REF 1 and REF 2 (plausible/ambitious) scenarios. The difference between them represents the potential increase in market demand resulting from higher global population. It is assumed that market demand equals supply. Emissions associated with this difference in demand are determined by applying standard emissions factors for conventional technologies/practices, e.g., grid emissions factors based on the global mix of coal-, oil- and gas-fired plants, or fuel combustion factors by fuel type. The analysis also includes indirect (embodied) emissions for implementation units required to meet the increased demand.

Results from each solution-specific model are then aggregated into a Population Emissions model, to determine the effects of the Health and Education solutions on total emissions reduction.

Each tab in the Population Emissions model workbook represents a specific cluster. Clusters included in the model are those for which TAM data are directly dependent on per capita consumption, and are therefore sensitive to changes in population numbers over time. Estimated changes to the TAM are a function of multiple factors, including population, economic conditions, policies and regulations, primary energy prices, infrastructural capacity, technologies costs and a host of other variables that impact individual and group preferences, such as culture, location, media, etc. Because many factors are difficult to model due to high variability across time and populations, population growth and economic conditions are the only factors considered to directly impact the size of the TAM in Project Drawdown models. The models therefore either directly use or harmonize the REF 2 population projections for determining their energy forecasts.

The different clusters included in the Population Emissions model shown in Table 5 below. Each cluster uses a Functional Unit of Measure, to best represent the outcome produced, or ‘function’ of the solution. This differs from the Implementation Unit of Measure, which best represents the number of acquisitions and installations, or ‘implementations’ of the solution. The two units are closely related: the implementation unit produces the function that is in demand.

For most of Project Drawdown’s models, data estimates used for different clusters are aggregated to correspond to the IPCC (AR5) regional classification, which are then used to identify LLDC and MDC regions.

Table 5: Different clusters included in the Population Emissions model

Cluster	Functional Unit	Implementation Unit	Emission factors
Electricity generation	Terawatt Hours (TWh) of electricity generated	Terawatts (TW) of capacity installed	Grid
Space Heating			Grid + Fuel
Space Cooling			Grid
Clean cookstoves			Fuel
Commercial lighting	Petalumen-hours of LED Lighting	Petalumens of LED Lighting installed	Grid + Fuel
Residential lighting	Petalumen-hours of LED Lighting	Petalumens of LED Lighting installed	Grid + Fuel
Water heating			Grid + Fuel
Paper- water heating			Other direct + indirect
Water			Grid
Plastics			Other direct
Transportation*	Passenger kilometers (pkm) traveled	Number of vehicles in use	Grid + Fuel
Nautical freight*			Fuel
Ground freight*	Ground freight transported (billion tonnes/km)		Fuel
Air km*			Fuel
Food demand			

\* IEA regional classifications used as a proxy for IPCC regions due to the absence of IPCC regional data for these clusters

### 2.3.2 Adoption Scenarios for population

Individual adoption scenarios for family planning uptake or universal educational attainment were not developed due to a lack of existing prognostications from external sources. Additionally, the high variability between different population change measures in terms of location, implementation, and scale prevent accurate estimations of adoption required for this analysis. Instead, the analysis in this section presents a few adoption scenarios for fertility changes and population shifts over time that occur as a result of the adoption of family planning and universal education. For this, we adopt a blend of the latest UN 2019 estimates for High, Medium, Constant and Low Population Variants, depending on the NRR and economic status of countries.

Countries are classified as high, intermediate or low-fertility based on their net reproduction rate (NRR) in 2020. NRR measures the average number of daughters that would be born to a female if she passed through her lifetime conforming to the age-specific fertility and mortality rates of a given year in her country of residence. When  $NRR=1$ , fertility is at replacement level given the mortality prevalent at the moment. Low-fertility countries therefore have an  $NRR < 1$ , that is, countries that already have below-replacement fertility. High-fertility countries are defined as

those with an NRR  $\geq 1.5$  children per woman, given that rate yields an increase of 50% each generation, holding fertility and mortality constant. The rest (NRR  $>1$  and  $<1.5$ ) are called “intermediate-fertility countries”. Table 5 shows the classification of countries according to NRR according to UN Population Division’s 2019 revision.

Impacts of increased adoption of education and family planning from 2020-2060 are generated based on three growth scenarios, which is assessed in comparison to a reference scenario (REF 1) where there is minimal increased adoption of education and family planning . A combination of the high and constant fertility variants (across countries of high/intermediate and low NRR, respectively) represents the Drawdown REF 1 scenario for health and education, where adoption barriers to universal education and family planning uptake continue to exist and no additional investments are made in improving reproductive health resources or closing the gender gap in primary/secondary education.

The Drawdown REF 2 (Plausible/Ambitious) population scenario factors in a combination of the UN medium and low-fertility variants (across countries of high/intermediate and low NRR, respectively), which represents declining a fertility trend attributable to the effective global adoption of family planning and education. (For the Health and Education sector, we make no distinction in outcomes between the Plausible and Ambitious scenarios and treat them as the same in terms of effort and advocacy for improved access to education and health for all).

The Maximum scenario is calculated based on the most ambitious and optimistic outcome in terms of increased education and uptake of family planning globally, resulting in the largest reduction in population growth possible. The Maximum scenario assumes that countries with current high NRR rates move from a high to medium population variant, while countries with both intermediate and low NRR rates move to a low population variant, as a direct result of family planning uptake.

Table 6: REF 1 and REF 2 scenarios according to fertility classifications and NRRs of different countries

Fertility Classification NRR of countries	UN population variant		
	REF 1 scenario	REF 2 (Plausible/Ambitious) scenario	Maximum scenario
High (NRR $\geq 1.5$ )	High variant	Medium variant	Medium variant
Intermediate ( $1.5 > \text{NRR} \geq 1$ )	High variant	Medium variant	Low-fertility
Low (NRR $< 1$ )	Constant-fertility	Low-fertility	Low-fertility

### 2.3.3 Total addressable market and PDS scenarios for emissions reductions

The total functional demand globally of goods and services represents the Total Addressable Market (TAM), which is composed of all technologies/practices (including the conventional mix and all possible solutions) that provide the same function within a given sector. TAM estimates for the different Drawdown sectors and solutions are derived from energy models (e.g. AMPERE3-MESSAGE, IEA, Greenpeace etc.), travel mobility or freight movement models, land area models, and food demand and waste estimations. For example, the TAM for the electricity generation market consists of coal- and gas-fired plants, plus solar, wind, geothermal, biomass, nuclear, etc. while lighting demand is a function of the global market for petalumen-hours of lighting supplied by multiple technologies, including incandescent, halogen, HID, LFL, CFL, and LED lighting.

Based on TAM data, three PDS scenarios represent the emissions outcomes for when global adoption of a particular climate solution occurs. For these, adoption is analyzed based on the functional demand for the solution at a global level and forecasted over the horizon from 2015 to 2060 using best available TAM data. Inherent in this approach is the core assumption that all policy and financial levers, infrastructure development, and consumer will that is required to reach this level of adoption will be met. Under the Project Drawdown framework, different levels of adoption for each scenario are defined as:

- **Plausible Scenario (REF 2):** the case in which universal education and access to voluntary family planning are adopted at a realistically vigorous rate over the time period under investigation, adjusting for estimated economic and population growth.
- **Ambitious Scenario:** the case in which universal education and access to voluntary family planning is optimized to achieve drawdown by 2050. For the Health and Education sector, we make no distinction in outcomes between the Plausible and Ambitious scenarios and treat them as the same in terms of effort and advocacy for improved access to education and health for all.
- **Maximum Scenario:** the case in which the health and education solutions achieve their maximum potential- meaning all children around the world are able to enroll and complete 12 years of quality education, and all women and men are able to access family planning services to enable them to choose if and when they want to have children.

### 2.3.4 Financial inputs

Financial inputs were not included for the education or family planning solutions, as costs (direct and indirect) are highly complex, variable by country and type of intervention (e.g., contraceptive method type, reproductive health services, level of education, etc.). Additionally, the links

between education and family planning, the impact of each and both solutions on population changes, and the resulting changes to emissions are complex and closely intertwined, hence the direct costs associated with each solution are difficult and at times impossible to ascertain. Estimated costs associated with progress in each of the sectors over time are described in Section 1.3 and 1.4; however, these estimations are exogenous to model used to determine population estimations and associated emissions reductions.

### 2.3.5 Terms and Assumptions in the model

- The effect of education on GHG emissions in the emissions model is calculated through classifying regions based on lower or higher educational attainment. Low educational attainment is defined as <50% of girls and boys completing upper secondary education.
- The effect of family planning on GHG emissions is estimated based on whether countries have a high or low net reproductive rate (NRR). More developed countries (MDCs) have low NRRs, defined as  $NRR < 1$ , while least and less developed countries have high NRRs ( $NRR \geq 1$ ).
- The conventional scenario represents the emissions outcome when no additional climate solutions are adopted or implemented, and the current status quo continues unchanged over time.

The table below outlines the different definitions, terms and assumptions that underlie the different scenarios.

Table 7: Definitions and terminology included in the Population Emissions model

Term/acronym	Definition/meaning	
LLDC	Least and Less Developed Countries	
MDC	More Developed Countries	
NRR	Net Reproductive Rate	
LAC	Latin American Countries	
EE	Eastern Europe	
LLDC+HighNRR+HigherEd	Least and Less Developed Countries with High Net Reproductive Rates & Higher Educational Attainment.	NOTE: China, LAC, and EE are considered as LLDC Regions with Low NRR and are accounted for under the _MDC sheet.
LLDC+HighNRR+LowEd	Least and Less Developed Countries with High Net Reproductive Rates & Lower Educational Attainment. This excludes China, LAC, and EE.	
MDC+EE+LAC+ LowEd	More Developed Countries + EE + LAC with lower educational attainment. This excludes China	

MDC+EE+LAC+ HigherEd	More Developed Countries + EE + LAC + China with higher educational attainment	
REF1	Reference Scenario 1 with Higher Population	
REF2	Reference Scenario 2 with Lower Population	
TAM	Total Addressable Market*	
TWh	Terrawatt-Hours	
Conventional	Adoption of only conventional, existing solutions/technology, maintaining current status quo	
Solution	Adoption of new solutions + conventional, existing solutions/technology in the sector	
Functional units	Each cluster uses a Functional Unit of Measure, to represent the outcome produced, or 'function' of the solution	
Implementation units	Represents the number of acquisitions and installations, or 'implementations' of the solution. Closely related to functional units, in that the implementation unit produces the function that is in demand	
$[y_1, y_{max}]$	The range of years of the analysis	[2020,2050] in the model
$Pop^{REF\ 2}$	Total population in the REF 2 scenario	In numbers of people (billions)
$Pop^{REF\ 1}$	Total population in the REF 1 scenario	In numbers of people (billions)
$TAM^{REF\ 2}$	Total addressable marker in the REF 2 scenario	
$TAM^{REF\ 1}$	Total addressable marker in the REF 1 scenario	
$Grid\Delta_y$	Reduction in $CO_2eq$ grid emissions for year $y$	In Gt $CO_2eq$
$Fuel\Delta_y$	Reduction in $CO_2eq$ fuel emissions for year $y$	In Gt $CO_2eq$
$ODirect\Delta_y$	Reduction in $CO_2eq$ other direct emissions for year $y$ (that is, not grid or fuel emissions)	In Gt $CO_2eq$
$Indirect\Delta_y$	Reduction in $CO_2eq$ indirect emissions for year $y$	In Gt $CO_2eq$
$E\Omega_y$	Reduction in energy usage for year $y$	In Exajoules/ EJ
$FU\Delta_y$	Reduction in annual functional units	In Functional Units
$EF_y^g$	Emissions factor of the grid in year $y$	In MMT $CO_2eq$ per TWh of electricity supplied
$EF^f^c$	Emissions factor of the fuel used by the conventional technology, assumed constant	In t $CO_2eq$ / TJ or t $CO_2eq$ / liter
$EF_{con}^{OD}$	Other direct emissions factor of the conventional technology besides grid and fuel emissions	In t $CO_2eq$ / functional unit
$EF_{con}^{Ind}$	Indirect emissions factor of the conventional technology	In t $CO_2eq$ / functional unit or t $CO_2eq$ / Implementation Unit

\*It should be noted that regional and global TAM estimates in each cluster may come from different sources and therefore the sum of all regional estimates may not always be equal to the global TAM estimate

### 2.3.6 Emissions calculations

To assess the impact of health and education on the overall emissions for each cluster and sector, the TAM data from each solution-specific model (grouped by IPCC regions) are regrouped

according to economic development status, which is a combination of development status (LLDC or MDC) and NRR. To give an example, the IPCC regions Asia (sans Japan, sans China) and the Middle East and Africa are grouped under the LLDC + high NRR group, while OECD90 and Latin America are classified under the MDC + LAC + EE group. For the REF 1 scenario, a further regrouping is then done by education attainment, which is calculated based on data from UNICEF on <50% educational completion for upper secondary schooling across different regions. In the REF 1 scenario, regions in both the LLDC + high NRR and MDC + EE + LAC can be of either low or high educational status (denoted by Low Ed or High Ed). In the REF 2 (plausible/ambitious) scenario, it is assumed that all regions belong to the High Ed category, implying educational attainment in all regions has reached a level high enough to contribute to the reduced population estimates of the REF 2 (plausible/ambitious) scenario (Tables 1-3 in the emissions model worksheet)

TAM estimates for the REF 2 scenario are imported into the Population Emissions model from the different respective solution models and clusters, shown in Table 5. TAM estimates for the Low Ed REF 1 scenario are calculated based on the UN REF 2 population estimates and the educational attainment groupings. For each IPCC region, this is denoted by:

$$(1) TAM^{REF1} = \left( \frac{TAM^{REF2}}{Pop^{REF2}} \right) \times Pop_{Low\ Ed}^{REF1}$$

Similarly, for the High Ed Ref 1 scenario, TAM estimates are derived by:

$$(2) TAM^{REF1} = \left( \frac{TAM^{REF2}}{Pop^{REF2}} \right) \times Pop_{High\ Ed}^{REF1}$$

Once TAM data have been regrouped according to economic development status, total energy demand for each cluster in the REF 1 and 2 scenarios is grouped by economic development status and educational attainment (Tables 4-5 in the Population Emissions worksheet).

$$(3) E\Omega_y^{REF1} = E\Omega_{y\ Higher\ NRR}^{REF1} + E\Omega_{y\ Lower\ NRR}^{REF1}$$

where

$$(a) E\Omega_{y\ Higher\ NRR}^{REF1} = E\Omega_{y\ LLDC+Low\ Ed}^{REF1} + E\Omega_{y\ LLDC+High\ Ed}^{REF1}$$

$$(b) E\Omega_{y\ Lower\ NRR}^{REF1} = E\Omega_{y\ MDC+LAC+EE+Low\ Ed}^{REF1} + E\Omega_{y\ MDC+LAC+EE+China+High\ Ed}^{REF1}$$



$$(4) E\Omega_y^{REF2} = E\Omega_y^{REF2}_{LLDC} + E\Omega_y^{REF2}_{MDC+LAC+EE+China}$$

For the REF 1 and 2 scenarios, the percentage of energy demand attributed to LLDC is calculated by dividing the total energy demand by the energy demand for LLDC + High NRR regions (for REF 1, with low or high Ed, respectively).

$$(5) \%E\Omega_y^{REF1}_{LLDC} = \left( \frac{E\Omega_y^{REF1}_{LLDC+High\ NRR+High\ Ed} + E\Omega_y^{REF1}_{LLDC+High\ NRR+Low\ Ed}}{E\Omega_y^{REF1}} \right) \times 100$$

$$(6) \%E\Omega_y^{REF1}_{MDC} = 1 - \%E\Omega_y^{REF1}_{LLDC}$$

$$(7) \%E\Omega_y^{REF2}_{LLDC} = \left( \frac{E\Omega_y^{REF2}_{LLDC+High\ NRR}}{E\Omega_y^{REF2}} \right) \times 100$$

$$(8) \%E\Omega_y^{REF2}_{MDC} = 1 - \%E\Omega_y^{REF2}_{LLDC}$$

The difference in energy demand for each cluster between the REF 2 and REF 1 scenarios is then calculated, together with the percentage of energy demand attributed to LLDC and MDC regions, and those with high educational attainment and low educational attainment (Table 6)

$$(9) E\Delta_y = E\Omega_y^{REF1} - E\Omega_y^{REF2}$$

Next, the differences in total functional demand of conventional technologies/practices are calculated. This is done across the REF 1 and REF 2 scenarios in LLDCs with high and low educational attainment and MDCs (changes in functional demand of the different *solutions* across clusters is not calculated due to the complexity of the computations, and hence differences in implementation units are not factored into any of the calculations).

The percentage increase in TAM for MDC + LAC + EE + China, LLDC + Higher NRR + High Ed and LLDC + Higher NRR + High Ed regions is computed based on the differences in functional demand between the REF 1 and REF 2 scenarios.

$$(10) FU\Delta_y = TAM_{con}^{REF1} - TAM_{con}^{REF2}$$

In order to compute the reduction in emissions that result from the entire health and education sector, avoided emissions for each cluster are calculated according to whether they are based on grid emissions or fuel emissions. For each cluster, the TAM mix (table at the top of each cluster sheet) indicates if the energy sources for that cluster are grid or fuel based, or from other direct or indirect sources, and if each of the energy sources are included in the conventional technologies/practices. For example, emissions from the electricity and lighting clusters are grid based, while for the clean cook stoves cluster, they are fuel based. For the space heating, space cooling and water heating clusters, emissions are both grid and fuel based (indicated in Tables 9 and 13), while for the paper and plastics clusters, avoided emissions come from other direct or indirect sources.

The total emissions reduction in LLDCs and MDCs are then calculated by adding up the reductions in grid, fuel and/or direct and indirect emissions under the conventional technologies/practices for each cluster.

$$(11) \sum_{y=y_1}^{y_{max}} R_y^{CO2e} = \sum_{y=y_1}^{y_{max}} [Grid\Delta_y + Fuel\Delta_y + Direct\Delta_y + Indirect\Delta_y]$$

$$(12) \sum_{y=y_1}^{y_{max}} Grid\Delta_y = \sum_{y=y_1}^{y_{max}} [FU\Delta_y \cdot EF_y^g]$$

$$(13) \sum_{y=y_1}^{y_{max}} Fuel\Delta_y = \sum_{y=y_1}^{y_{max}} [FU\Delta_y \cdot EF_y^f]$$

$$(14) \sum_{y=y_1}^{y_{max}} Direct\Delta_y = \sum_{y=y_1}^{y_{max}} [FU\Delta_y \cdot EF_{con}^{OD}]$$

$$(15) \sum_{y=y_1}^{y_{max}} Indirect\Delta_y = \sum_{y=y_1}^{y_{max}} [FU\Delta_y \cdot EF_{con}^{Ind}]$$

Emissions for the demand-side food cluster are calculated using the Food model, which incorporates global demand for food, required supply to meet that demand (accounting for food waste that occurs post farm-gate), required land conversion (either to or from agricultural production) to supply the food, and the combined emission impacts from agricultural production

and land conversion. Impacts are modeled for 176 countries across 95 food commodity categories using data collected by the FAO, applying global average life cycle assessment (LCA) values to the estimated post-farm gate supply of those commodities. Country-level emissions and food supply results are then aggregated to yield global results, by converting caloric intake for various food commodities to population-level emissions impacts by country. This emissions data is then imported directly into the Population Emissions model.

In terms of allocating the impact of education and health on the overall reductions in emissions, in LLDC + High NRR + High Ed countries, and the MDC + LAC + EE + China, overall reductions in emissions are attributed to adoption of the health solution (family planning) alone, as educational attainment in these countries is assumed to be high. In LLDC + High NRR + Low Ed countries, emissions reduction attributed to health and education solutions is assumed to be 50%:50%, since we have no way of accurately ascertaining the individual impact of improved education solutions or health solutions on population changes due to the highly interlinked and complex relationships between the two sectors.

The final step in estimating the total emissions reduction from adoption of the health and education solutions is to calculate the cumulative emissions reduced (in GTs) for the years 2020 to 2050, across all clusters, for both LLDC and MDC regions.

## 2.4 DATA SOURCES

The table below provides an overview of the data sources drawn on for the models and estimates for the Health and Education sector

Table 8: Data sources used for estimates and projections for the Health and Education sector

Model Component	Unit	Data Host	Data Set	Link	Source
Population changes	Total population (both sexes combined) for 1950-2100 (thousands)	UN Data: United Nations Population Projections	World Population Prospects 2019, standard projections (population data, overall total population-both sexes)	<a href="https://population.un.org/wpp/Download/Standard/Population/">https://population.un.org/wpp/Download/Standard/Population/</a>	UN Department of Economic and Social Affairs, Population Dynamics
	Net Reproductive Rate	UN Data: United Nations Population Projections	World Population Prospects 2019, standard projections (fertility data, summary indices, NRR)	<a href="https://population.un.org/wpp/Download/Standard/Fertility/">https://population.un.org/wpp/Download/Standard/Fertility/</a>	UN Department of Economic and Social Affairs, Population Dynamics
	Country groupings based on SDG and UN subregions, World Bank Income groups	UN Data: United Nations Population Projections	World Population Prospects 2019, metadata (documentation-locations)	<a href="https://population.un.org/wpp/Download/Metadata/Documentation/">https://population.un.org/wpp/Download/Metadata/Documentation/</a>	UN Department of Economic and Social Affairs, Population Dynamics
Educational attainment	Gender parity upper secondary school completion	UNICEF Data	School completion rates Nov 2019	<a href="https://data.unicef.org/topic/gender/gender-disparities-in-education/">https://data.unicef.org/topic/gender/gender-disparities-in-education/</a>	UNICEF Data: Gender and education
	Gender parity primary and lower secondary school completion	UNICEF Data	School completion rates Nov 2019	<a href="https://data.unicef.org/topic/gender/gender-disparities-in-education/">https://data.unicef.org/topic/gender/gender-disparities-in-education/</a>	UNICEF Data: Gender and education
	Educational attainment across genders	UNICEF Data	School completion rates Nov 2019	<a href="https://data.unicef.org/topic/gender/gender-disparities-in-education/">https://data.unicef.org/topic/gender/gender-disparities-in-education/</a>	UNICEF Data: Gender and education
Financials	Costs of family planning	Guttmacher Institute	Costs per contraceptive user, 2019	<a href="#">Adding It Up: Investing in Sexual and Reproductive Health 2019   Guttmacher Institute</a>	Guttmacher Institute. Adding It Up: Investing in Sexual and Reproductive Health 2019- Appendix Tables

Costs of education	UNESCO: Global Education Monitoring Report	Cost analysis for achieving the SDGs (page 296)	<a href="https://unesdoc.unesco.org/ark:/48223/pf0000232205">https://unesdoc.unesco.org/ark:/48223/pf0000232205</a>	2015 Global Education Monitoring Report
	OECD 2020	Total expenditure on education institutions per full time student (2017, page 280)	<a href="https://www.oecd.org/education/education-at-a-glance/">https://www.oecd.org/education/education-at-a-glance/</a>	Education at a Glance 2020: OECD indicators

## 2.5 LIMITATIONS TO THE METHODOLOGY AND MODEL

### 2.5.1 UN population projections

The UN's population projections are based on the demographic transition theory. However, it is very possible that the development paths of low income countries, especially those in SSA will not followed the trajectory theorized in the demographic transition theory. Therefore, despite increase in educational attainment and improved family planning service provision, fertility in regions such as SSA may not fall as rapidly as has been set forth in the projections.

Projections of regional population changes over time are also based on an aggregate of data for fertility, mortality and migration estimates from different empirical country data sets, many of which may have inconsistent or missing data as a result of different methods and time points of data collection and documentation. The UN Department of Economic and Social Affairs acknowledges this limitation, as stated in the World Population Prospects 2019 methodology report: "considerable effort has been devoted to evaluating, analysing and reconciling empirical evidence to produce consistent and reliable estimates. However, in the absence of perfect demographic data, it should be noted that there is still a degree of uncertainty associated with the estimates of the population and related fertility, mortality and international migration indicators within many countries, especially in earlier decades."(United Nations Population Division, 2021)

### 2.5.2 Regional grouping of countries

IPCC regional data are used in Drawdown's models due to the lack of accurate country-level TAM estimates for the different clusters. The use of IPCC regions to group countries together by educational attainment or NRR however, assume that all countries within the region fall under the same grouping, which may not always be the case. For example, Latin America as a region overall is assumed to have a low NRR, but some countries within the region have an intermediate NRR, such as Argentina and Mexico. Similarly, Middle East and Africa is collectively assumed to have a high NRR, but countries included in the region, such as Djibouti and Qatar, have intermediate and low NRRs, respectively.

### 2.5.3 Inconsistencies between data from different sources

Projections and estimates for family planning uptake, educational attainment and population shifts are modelled by different organizations using a variety of data sources, many of which do not follow the same region/country grouping. For instance, projections for family planning use

are computed by UN DESA for geographical and SDG regions, while Drawdown's modelling is based predominantly on IPCC regions. Given the different ways in which countries are grouped based on different regional classifications, comparing and harmonizing data in the analyses is sometimes a challenge.

#### 2.5.4 Incomplete data

Data on NRR are not available for several small island/developing states. Given the small populations in these countries, the UN medium population variant estimates were used in computing both the REF 1 and REF 2 scenarios, based on the assumption that the populations in these countries will not change significantly over time.

## 3 RESULTS

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### 3.1 CHANGES IN POPULATION ESTIMATES OVER TIME

Based on estimates from the UN 2019 Revision of World Population Prospects, the REF 1 and REF 2 scenarios and projections across time for population growth are shown in Table 6 below. For comparison purposes, population estimates derived from the previous UN 2015 population projections are shown in Table 7.

Table 9: Changes in population estimates (in billions) across different scenarios, based on 2019 UN Population Projections

2019 Population estimates (billions)				
Scenario	2015	2020	2050	2060
REF 1	7.37	7.79	10.29	11.07
REF 2	7.37	7.79	9.43	9.71
<i>Difference</i>	0	0	0.86 (8.36% ↓)	1.37 (12.38% ↓)

Table 10: Changes in population estimates (in billions) across different scenarios, based on 2015 UN Population Projections

2015 Population estimates (billions)				
Scenario	2015	2020	2050	2060
REF 1	7.35	7.79	10.39	11.23
REF 2	7.35	7.73	9.38	9.70
<i>Difference</i>	0	0.06	1.01 (9.72% ↓)	1.54 (13.71% ↓)

2017 Population estimates (billions)				
Scenario	2015	2020	2050	2060
REF 1	7.38	7.83	10.43	11.27
REF 2	7.38	7.77	9.43	9.74
<i>Difference</i>	0	0.06	1.00 (9.59% ↓)	1.53 (13.58% ↓)

A few key differences observed in the projected population trends of the 2019 UN estimates, compared to the previous iteration from 2015, is a slight increase in the REF 2 population estimates, and a decrease in the REF 1 estimates for the years 2050 and 2060.

The difference between REF 1 and 2 populations (shown by the percentage reduction in estimates) for 2019 (0.86 billion, or a decrease of 8.36% between the scenarios) is also smaller



compared with 2015 estimates (1.01 billion, a decrease of 9.72% between the scenarios), and constitutes a 14.85% decrease between 2015 and 2019  $[(1.01-0.85/1.01)*100]$ .

### 3.2 EMISSIONS REDUCTION IMPACT

In Project Drawdown's Plausible/Ambitious Scenarios for 2021, Health and Education solutions contribute towards a reduction in **69.9** GT of GHG emissions (Table 8). In the Maximum Scenario, they contribute towards a reduction of XX percent.

Compared with the estimates of GHG reduction from 2015, the 2019 estimates are a reduction of about 18.1%  $[(85.4-69.9/85.4)*100]$ . Based on the difference of 14.85% in population estimates mentioned in the preceding section, this reduction in GHG emissions corresponds to app 1.20% decrease in GHG emissions for every 1% decrease in population estimates.

Table 11: Emissions Reductions (GTs) of the Health and Education Sector Solutions

	<b>Plausible/ Ambitious Scenario</b>	<b>Maximum Scenario</b>
2015	83.2	
2019	85.4	
2021	<b>69.9</b>	<b>88.9</b>

Reductions in GTs due to population changes under the Plausible/Ambitious Scenario across the different sectors are shown in Table 9 below.

Table 12: Emissions Reductions across different sectors under the Plausible Scenario

<b>Solutions</b>	<b>Gigatons CO2-eq</b>
<b>Population Change, by other sector</b>	
<i>Electricity Generation</i>	
<i>Buildings</i>	
<i>Transportation</i>	
<i>Materials</i>	
<i>Food System</i>	
<i>Land use*</i>	0
<b>TOTAL</b>	<b>69.9</b>

\*NOTE: land usage and related emissions are determined by estimations of Total Land Area (TLA) based on hectares of land in different land types, agroecological zones, and thermal-moisture regimes derived from data provided by the Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis. Due to the high level of uncertainty related to the higher population scenario, land availability, and resource constraints, emissions reductions related to the land use sector were not included in this analysis.

## 4 DISCUSSION

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Today, an estimated 7.8 billion people inhabit this planet. By 2050, this number will undoubtedly increase, but how dramatic this increase will be, as well as the consequences of this increase in terms of emissions, climate change and planetary health, remains to be seen. Despite a backdrop of improved societal structure and advances in infrastructure and technology, the demand, production and consumption of food, water, energy, and other resources will increase as the global population increases. While acknowledging that countries and regions with high population growth are not always the same countries and regions contributing most towards GHG emissions, reducing the overall momentum and scale of global population growth is a definitive way to reduce the negative impacts of climate change on the planet. One of the most effective and certain rights-based approaches that slow unchecked population growth, through preventing unintended or unwanted pregnancies, is ensuring access to voluntary family planning and universal education for all.

As this TR has outlined, there are a few different scenarios that could unfold by 2050, depending on a combination of factors. Demographic factors such as population growth, the age structure of populations, the demographic dividend, urbanization, and household size all have a role to play in determining overall emissions over time. Beyond the profound societal benefits in advancing women's empowerment, human rights and equity, the health and education sector solutions outlined in the preceding sections directly impact unsustainable population growth that is critical to mitigating climate change through reducing overall emissions. Although there is a lack of consensus on the precise significance and weight of the various interactions between education, family planning uptake, and fertility outcomes over time, it is evident that these interventions are important yet often overlooked contributors toward the drawdown of GHG emissions.

As mentioned above, it is important to recognize that while population growth maybe highest in LMICs, emissions per capita are greatest in high-income countries. As LMICs progress through the different stages of the demographic transition, their demand, production and consumption patterns will mirror those that we see in high-income countries today. This effectively means that even if population growth rates slow in LMICs, their contribution towards global emissions may increase due to an increase in per capita emissions. The emissions reductions possible in the different Drawdown scenarios in low fertility countries are much greater than those in medium and high fertility countries combined. Therefore, it is important that strategies focused on changing emission patterns are alongside health and education sector solutions focused on reducing the total number of future emitters. Climate and planetary health education is key to achieving this; if today's children and youth are educated and encouraged to actively participate

in climate action and leadership, they will have the skills, mindsets and understanding to adopt behaviors that will enable their future families and communities better adapt to climate change.

## 4.1 KEY HIGHLIGHTS

- The PDS models have been updated with the latest UN population projections from 2019. Estimates now indicate that in a Plausible/Ambitious scenario, adoption of the Health and Education solutions result in a decrease of 69.9 Gt of GHG emissions. The difference in estimates between 2015 and 2019 of an 18% reduction in global population by 2050 will likely result in a 15% reduction in GHG emissions.
- While rates of educational attainment and uptake of voluntary family planning have improved in recent years through concerted efforts and investment, there is still much to be done in order to ensure equitable access to universal education and quality SRHR services globally. Regional disparities continue to exist, particularly in SSA and low-resource settings.
- In order to inch closer towards the Plausible/Ambitious and Maximum scenarios, sustained and collaborative initiatives focused on reducing poverty, addressing urbanization, increasing funding for both education and SRHR services, and advancing climate and planetary education will be critical. The COVID-19 pandemic has had drastic effects on development and investment in all of these areas, and the next few years are likely to see slow progress on this front as the world rebounds and recovers from the pandemic.

## 4.2 LIMITATIONS

In attempting to provide a comprehensive and technical overview of the Health and Education sector of Project Drawdown, some areas remain unexplored and outside the scope of this TR. For instance, while advocating for universal education and 12 years of complete schooling for both girls and boys, the direct impact of boys' education on fertility decisions, as well as choices about family size, the spacing of children, and the voluntary uptake of family planning is currently unknown. This is due to the measure of fertility inherently tied to women's reproductive choices and birth outcomes, as well as the difficulty in quantifying the role of men in decisions around family planning uptake and SRHR. To date, there have also been very few studies that have focused on the association between universal education and population shifts over time, mainly due to the complexity and multi-level relationships that exist in this domain.

Financial estimates have not yet been incorporated into the population emission model, and therefore the costs involved for implementing the solutions in this sector are yet to be

determined. Again, this is due to challenges in accurately estimating the dynamic and complex costs of providing quality education and health services that are accessible to all. In similar vein, the impact of global, regional and national policies, directives and funding on the education and health was not analyzed in this report, due to the depth and breadth of that analyses being outside the scope of this TR.

It is also important to reiterate that the methodology and research that form the foundation of Project Drawdown's work is constantly evolving and changing based on new data, improved modelling and new, innovative solutions in the field of climate change. As such, the estimates and information provided in this report are an accurate reflection of the most current and updated TAM and population projections that are available. Yet these numbers are bound to change in the months and years to come and may look very different in the near future, particularly in light of the way the world has changed and reacted to the COVID-19 pandemic and while different nations, sectors and societies continue to recover in their own way. By the same token, Project Drawdown's outcomes and outputs will continue to be guided by new data, technological advances and scientific discoveries to come.

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## 6 APPENDIX

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