K4DD Knowledge for Development and Diplomacy

The impacts of climate change on illicit drug cultivation

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How has climate change affected patterns of illicit drug cultivation globally, for example by affecting the livelihoods and incentives of potential growers or crop yields? Include evidence related to potential or emerging illicit drugs, gender, and migration, where available.

Contents

1 Summary

Climate change can create incentives for participating in illicit drug production by disrupting agricultural and natural-resource-based livelihoods and exacerbating social, economic, and political stresses and conflict. However, it is difficult to identify a precise causal relationship between the impacts of climate change and illicit drug production, and the effects of climate change appear to be limited compared with other driving forces. In Afghanistan, climate change is expected to contribute to rising temperatures, worsening water stress, and increasing frequency and severity of extreme weather events. Adverse effects of climate change and conflict on agricultural livelihoods and irrigation infrastructure have contributed to increased opium poppy cultivation, but farmers' decisions about growing poppies are strongly influenced by security, social, political, economic, technological, and market factors. Across Latin America, climate change is expected to cause increasing temperatures, significant changes in precipitation patterns, and water scarcity, which will strengthen incentives for illicit crop production. However, other factors including changing patterns of demand for drugs globally, rural poverty and limited economic opportunities, low and volatile prices for coffee and other agricultural commodities in international markets, and the legacy of conflict (in Colombia) appear to have greater influence than climate change on illicit crop production patterns.

Climate change is likely to have some limited effects on illicit crops on a biological level, but these effects are highly location-specific and growers have considerable ability to mitigate effects through crop breeding and changing agricultural practices. Cannabis plants are well-adapted to projected changes in atmospheric CO_2 concentrations and to drought conditions, but climate change is expected to produce varying effects in different areas across the USA and Canada and commercial cannabis farmers anecdotally report increasing variability and uncertainty in growing conditions. The Latin American coca belt is expected to become generally warmer and drier with local variations as a result of climate change, but this is not expected to have a significant effect on coca production. Opium poppies are well-adapted to drought conditions, and there is limited evidence that projected changes in atmospheric CO_2 concentrations could increase the concentration of opiates produced. Academic studies in Turkey anticipate little impact on the geographic range of poppy production within Turkey in the next fifty years, but poppy growing may become infeasible in some current growing areas after 2070. In Tasmania, Australia, on the other hand, there is an expectation that climate change could have a positive impact on poppy production.

Methamphetamine and fentanyl are having significant impacts on patterns of illicit drug production, but their emergence has been driven by market forces (changes in demand from drug users and production costs and processes) rather than by climate change. In Afghanistan, the manufacture of methamphetamine is growing and there is a possibility that this could incentivise poppy growers to change to cultivating ephedra to meet demand for the necessary inputs. Fentanyl is displacing heroin in North America because of its low cost and high strength, and this shift in demand is having significant impacts on opium producers in Mexico.

Climate change is recognised as a driver of migration, but there is little evidence linking climate-induced migration with changes in patterns of illicit drug production. When examples of migration are discussed in the literature on illicit drug production, the forces described as driving migration are generally factors other than climate change, and the effects on drug production are few.

Limited evidence suggests that illicit drug production can offer livelihood alternatives for women, but does not make a link to the impacts of climate change.

International climate policy does not engage with the subject of illicit drugs, and there is limited interaction between agencies working on drug policy and enforcement, and agencies working on climate and environmental issues. 'There is no mention of drugs in any of the recent global climate or biodiversity agreements and within drug policy circles, environmental issues have, until very recently, only been debated at the margins. This disconnect stems from an institutional sequestering of drugs within the framework of crime and law enforcement' (Kay, 2022, p. 6). Recent publications in the United Nations Office on Drugs and Crime (UNODC) illicit crop monitoring report series reviewed during the production of this report do not discuss the impacts of climate change on drug production, although the UNODC has produced reports addressing the impact of drug production on the environment. A study focusing on coca production reported that as of 2014 the US Drug Enforcement Agency, the UNODC, and the Inter-American Drug Abuse Control Commission all confirmed that their agencies had not examined the effects of climate change on coca (Smith & The Daily Climate, 2014).

There has been very little academic research published on the impacts of climate change on illicit drug production. There has been research into the impacts of climate change on various legal agricultural crops, but 'little effort has been spent exploring what an era of rising temperatures could mean for coca' (Smith & The Daily Climate, 2014). A more recent study notes that the illicit nature of cannabis 'has stunted scientific research on its production', but suggests that increasing liberalisation in North America and parts of Europe is beginning to enable research in this field (Caplan et al., 2019, p. 964). The majority of the evidence linking climate change with illicit drug production appears to come from small-scale, highly localised case studies. In the literature reviewed for this report, the impacts of climate change on illicit drug production are usually described in general terms as influences and tendencies; most studies were not able to identify causal relationships that were precise about the size of the effect produced for a given stimulus. (There is, however, a more substantial body of evidence about the impacts that illicit drug production has on climate change and the environment.)

Note on nomenclature of illicit drug crops

Cannabis is the botanical name of a genus of plants, the best-known of which is *Cannabis sativa*. Varieties of cannabis that have very low concentrations of the psychoactive chemical tetrahydrocannabinol (THC) and produce no hallucinogenic effects (the legal threshold varies among countries) are called **hemp**, which has a variety of non-drug-related uses. Varieties with higher concentrations of THC may be called **marijuana**, which can be used in herbal form or processed into **cannabis resin**, also known as **hashish** or **charas**.

Coca bush is a tropical shrub (*Erythroxylum coca* or *Erythroxylum novogranatense*). **Cocaine** is extracted from the leaves of the coca plant and used either in a powdered form or further processed to produce **crack**.

Opium poppies (*Papaver somniferum*) produce seed pods that contain a milky fluid, opium gum, which is collected and dried. The opium gum can be processed to extract **morphine**, which can be further processed to produce **heroin**.

(EMCDDA, 2022, 2023, 2024; Schilling et al., 2020)

2 Socio-economic incentives for growers

Climate change can create incentives for participating in illicit drug production by disrupting agricultural and natural-resource-based livelihoods and exacerbating social, economic, and political stresses and conflict. However, it is difficult to identify a precise causal relationship between the impacts of climate change and illicit drug production, and the effects of climate change appear to be limited compared with other driving forces. The impacts of climate change can incentivise people who depend on agriculture and natural resources to turn to illegal coping strategies (Detges et al., 2020, p. 21). However, in the literature reviewed for this report, the impacts of climate change on illicit drug production are usually described in general terms as influences and tendencies; no studies were able to identify causal relationships that were precise about the size of the effect produced for a given stimulus. Other social, economic, and political factors are much more prominent in the literature than climate change. Climate change is perhaps best viewed as a 'risk multiplier' that can 'exacerbate challenges such as rapid population growth and urbanisation, increase resource demands, environmental degradation and uneven development, and exacerbate existing fragility and conflict risks' (Detges et al., 2020, p. 11).

2.1 Afghanistan (opium poppies)

The poppy-growing situation in Afghanistan changed radically in 2022 when the Taliban banned all cultivation of poppies, leading to an 85% to 95% drop in production (Mansfield, 2023b; UNODC, 2023a, p. 3)*. The discussion below of growers' incentives refers to the period before the current ban was imposed.*

In Afghanistan, climate change is expected to contribute to rising temperatures, worsening water stress, and increasing frequency and severity of extreme weather events. Mean annual temperatures in Afghanistan have risen by about 1.5 °C since the beginning of the 20th century, and are expected to rise a further 1.5 to 5.8 °C by the end of the 21st century[1] (World Bank and Asian Development Bank, 2021, p. 7). Climate change

[1] These temperature ranges depend on assumptions about future fossil fuel use and efforts to mitigate climate change. The Intergovernmental Panel on Climate Change (IPCC) developed four scenarios (Representative Concentration Pathways, identified as RCP2.6, RCP4.5, RCP6.0, and RCP8.5) that are widely used in climate forecasting. The lower temperatures shown here arise from RCP2.6, which assumes that fossil fuel use will be greatly reduced and strong mitigation measures will be put in place. The higher temperatures arise from RCP8.5, which assumes high fossil-fuel use and no climate mitigation policies (Hausfather & Peters, 2020; World Bank and Asian Development Bank, 2021, p. 7).

has had severe effects on precipitation patterns across Afghanistan, leading to widespread water scarcity and persistent drought (Parenti, 2015, pp. 185–186; UNOCHA, 2023). Average annual precipitation is not expected to significantly change over the 21st century (World Bank and Asian Development Bank, 2021, p. 10), but higher temperatures are expected to increase evapotranspiration, exacerbate water stress, and further diminish groundwater resources (NUPI & SIPRI, 2022, p. 2), while mountain glaciers which feed rivers in the summer and during drought years are shrinking (IISS, 2019, p. 39; World Bank and Asian Development Bank, 2021, p. 13). Extreme heat waves are likely to become more frequent, chronic drought conditions are likely to affect larger areas of the country, extreme drought events could become two to three times more frequent, and flood risk is likely to increase (IISS, 2019, p. 39; World Bank and Asian Development Bank, 2021, pp. 12–14).

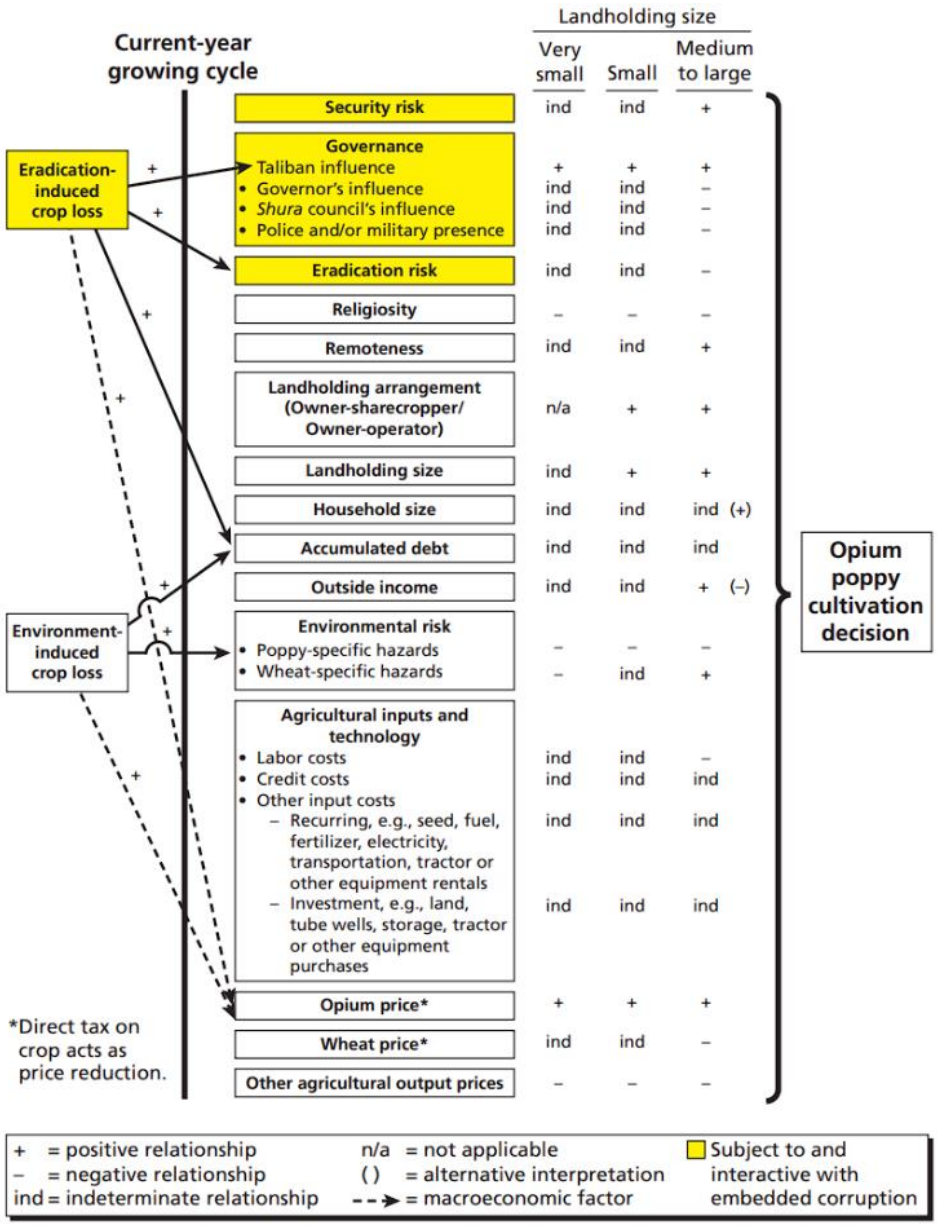
'**Adverse effects of climate change and conflict on agricultural livelihoods and irrigation infrastructure have contributed to increased opium poppy cultivation**' (NUPI & SIPRI, 2022, p. 3). Water scarcity is a strong incentive for growing poppies: they are highly drought-resistant, requiring only one-fifth to one-sixth as much water as wheat, and they are roughly three times more profitable per hectare than wheat (IISS, 2019, p. 39; Kienberger et al., 2017, p. 725; NUPI & SIPRI, 2022, p. 3; Parenti, 2015, p. 183). One study projecting cereal crop yields[2] suggests that the mean yield of wheat will decrease by 21% to 28%, rice by 5% to 6%, and barley by 387 to 535 kg/ha by 2050 (Sarwary et al., 2023, p. 1); the effect that this would have on grain prices is uncertain, as prices are also affected by global market conditions. An increase in the profitability of opium compared with wheat incentivises poppy-growing, and 'the price of wheat would need to quadruple, all else held constant, before wheat would look preferable to opium poppy as a cash crop' (Greenfield et al., 2015, pp. 76–79). Increases in the variability of returns from growing wheat could either increase or decrease the amount of land allocated to opium poppies: subsistence households are more likely to prioritise wheat, while households with larger landholdings are more likely to grow more poppies (Greenfield et al., 2015, pp. 72–73).

Farmers' decisions about growing poppies are strongly influenced by security, social, political, economic, technological, and market factors. Factors that affect a farmer's decision include security risks; governance; the risk of illicit crops being eradicated; environmental risks; religiosity; landholding remoteness, arrangements, and size; household size, debt, and income sources; environmental risks; agricultural input costs and technology; and prices for opium, wheat, and other commodities (Greenfield et al., 2015, pp. 39, 46) (see Figure 1). In the early 2000s, the area under poppy cultivation fluctuated widely depending on counternarcotics efforts, shifts in the price of wheat versus opium (affected by global market prices and restrictions on trade with Pakistan), and the availability of other opportunities in the legal economy (Mansfield, 2018, pp. 336–337). Opium poppy growing is associated with multi-dimensional poverty, lack of economic opportunities, limited access to markets, lower household earnings from legal crops, larger household sizes, lower crop and income diversification, and limited access to credit (UNODC, 2023a, p. 35). Technology, enforcement policies, and land prices can be important driving forces: between 2008 and

[2] The forecasts given here for all three crops are based on the IPCC's Representative Concentration Pathways RCP4.5 and RCP8.5.

2013, two-thirds of poppy production in Helmand moved from central fertile areas into desert areas known as the *dasht*, driven by the arrival of cheaper tube well drilling technology that enabled easier access to groundwater for irrigation, poppy eradication programmes that pushed growers into more remote locations, and low land prices in the *dasht* (Greenfield et al., 2015, pp. 18, 21–24). Political developments can also cause major changes in illicit drug cultivation patterns: in Afghanistan, the Taliban banned opium poppy production in 2022, and by 2023 poppy production was down by 85% to 95% (Mansfield, 2023b; UNODC, 2023a, p. 3), which is likely to create global shortages of opiates, raise the price of opium, create opportunities for growers in other countries to fill the demand (UNODC, 2023b, pp. iii, xi), and further stimulate demand for substitutes such as synthetic opioids (see section 4).

Figure 1: Factors influencing the opium poppy cultivation decision



Source: Greenfield et al., 2015, p. 46. Reprinted with permission.

2.2 Latin America (cannabis, coca, and opium poppies)

Climate change is expected to cause increasing temperatures, significant changes in precipitation patterns, and water scarcity across much of Latin America. Mean temperatures across Latin America are expected to rise by 1 to 4 °C by the end of this century[3]; precipitation patterns are likely to change across the region; heat extremes, aridity, and the intensity of tropical cyclones and other storms are all expected to increase; and increased drought conditions are foreseen in the Amazon basin, northeastern Brazil, Central America, the Caribbean and parts of Mexico (Abdenur & Rüttinger, 2020, p. 7). Coffee production is notably threatened by impacts of climate change: it has been estimated that 73% to 88% of the areas where Arabica coffee is currently cultivated will become unsuitable by 2050 due to climate change, with coffee farmers likely to cope by switching to growing Robusta coffee, which is hardier but produces a lower-quality (and lower value) product (Harvey et al., 2021, pp. 8, 11; IISS, 2019, p. 42). Coffee farmers' principal adaptation strategies include changing the variety of coffee that they grow, intensifying management of fields to obtain higher yields, abandoning plantations or converting them to other land uses, expanding into forested areas (leading to deforestation), and adopting sustainability standards that include increased presence of shade trees and forest cover (Harvey et al., 2021, pp. 6–9).

Climate change strengthens incentives for illicit crop production across Latin America. Lack of economic opportunities, marginalisation and state neglect fuel drug crop production and the drug trade in Latin America (Grisaffi & Farthing, 2021). Climate change can affect the viability of food and cash crops, contribute to the erosion of rural livelihoods, incentivise illicit coping strategies including illegal crop cultivation, and make it easier for drug trafficking organisations to displace communities to take control over agricultural land (Huber et al., 2023, p. 16). Central America is particularly vulnerable because its economy is highly dependent on agriculture and because of existing gang violence, inequality, social marginalisation, and low institutional capacity (Huber et al., 2023, p. 2). In such an environment, coca has been described as an 'almost ideal crop': it grows readily on steep slopes, in acidic soil and at altitude; it is light and easy to transport; it reaches maturity after a year and can be harvested every three to four months, demand is reliable, and it produces higher returns than any other crop (Farthing & Grisaffi, 2023, p. 4).

In Colombia, coca cultivation has been driven by global demand for cocaine, rural poverty, low global coffee prices, and slow recovery from fifty years of conflict. The area of land used for growing coca in Colombia grew from 62,000 hectare (ha) in 2010 to 204,300 ha in 2021 (UNODC, 2023c, tbl. 6.1.1). The increase has been driven by strong global demand for cocaine, multidimensional poverty and limited market access in coca-growing areas, weak implementation of Colombia's peace accords in the area of rural reform, expansion of drug trafficking groups filling power vacuums left by former rebel groups, and the lucrative income that can be made from cocaine production (UNODC, 2021, p. 7). Low and volatile global coffee prices have harmed coffee growers' livelihoods and

[3] These projections are based on IPCC scenario IS92a, sometimes called 'business as usual' because it assumes that greenhouse gas emission trends will continue without significant reduction measures or mitigation; this scenario was developed in the 1990s and has been supplanted by more recent scenarios.

threatened the viability of coffee farming to the extent that farmers have been induced to cultivate coca or move to coca-producing areas (Harvey et al., 2021, pp. 3, 7). One study in 2010 argued that the decline in coffee prices following the breakdown of the International Coffee Agreement (a quota system that stabilised global prices) in 1989 increased poverty in Colombia, opening up opportunities for drug traffickers and incentivising coca production (Rettberg, 2010). Despite investment in eradication and substitution programmes since 2016, coca production has increased in Colombia because 'farmers say they can earn ten times more growing coca than any other crop' (Dennis, 2017; Grandmaison et al., 2019, p. 31).

In Mexico, low crop prices, poor agricultural yields, limited economic opportunities, governance failures, and changing patterns of demand in the USA influence the cultivation of cannabis and opium poppies. For example, one study covering 2,296 municipalities found that a 59% drop in the price of maize[4] between 1990 and 2005 was associated with a 12% increase in cannabis plantation eradication (a proxy measure for production), a 5% increase in opium poppy eradication, an increase in seizures of marijuana, and increases in drug cartel operations, including killings (Dube et al., 2016, pp. 1181–1183). A second study, focusing on the Tarahumara indigenous community in Northern Mexico, found that climate change was responsible for drought, lower yields of beans and corn, and difficulty providing forage for cattle, which led to malnutrition and risk of famine. This created opportunities for drug traffickers to take control of land, operate in 'collaborative governance' with local government authorities, and press local people into working as drug smugglers or growers (Weisz Argomedo, 2020). A third study argues that increased price competition and the abolition of agricultural subsidies in the 1990s and 2000s made it difficult for small-scale Mexican farmers to compete with cheap food imports from the USA and elsewhere, leading many farmers to migrate to Mexican cities or to the USA and incentivising those who remained to grow 'the only remaining profitable crops': poppies and cannabis (Grandmaison et al., 2019, p. 6). Drug crop cultivation in Mexico also responds to changes in patterns of demand in the USA. In the early 2000s, legislation in the USA reduced access to legal medical opioids so addicts sought out heroin from Mexico as a replacement, and then when cultivation and use of cannabis began to be legalised in parts of the USA beginning in 2012, US-grown cannabis began to take over the market and reduce demand for Mexican cannabis. Together, these changes incentivised Mexican farmers and drug traffickers towards growing opium poppies (Grandmaison et al., 2019, p. 6).

In Bolivia, macroeconomic factors appear to have been more influential than climate change in incentivising coca production. One study in the coca-growing region of Chapare in Bolivia set out to investigate the link between climate change and coca production, and although it identified impacts of climate change that included greater variations in rainfall and higher risks of flooding, as well as trends of increasing cultivation of illicit drugs and drug trafficking activity, it was unable to establish a causal link. The study concluded that although climate and the spread of coca-related crime 'cannot be directly

[4] 'Maize has historically dominated the Mexican agricultural sector' and contributes to subsistence or employment for more agricultural workers than any other crop (Dube et al., 2016, p. 1189).

correlated… the dismantling of the social structure that guarantees access to income for citizens is an element that helps them move towards irregularity and illegality' (Closs, 2019, pp. 44–48). An earlier report suggested that coca growing in this region was stimulated by economic problems in the mining industry: 'in the 1980s, when the country's tin mining industry went bust… Miners and their families moved to the country's Chapare region and took up coca farming' because coca is easy to grow, can be cultivated several times a year, and is highly profitable (Smith & The Daily Climate, 2014).

In Peru, global commodity prices have been implicated in incentivising coca production. A slump in world coffee prices induced some coffee growers to begin cultivating coca or migrate to coca-growing areas of the country (Grisaffi & Farthing, 2021; Harvey et al., 2021, pp. 3, 7). One academic research team describes coca production in Peru as 'a lifeline for these farmers' (Grisaffi & Farthing, 2021), and a Peruvian association of coffee producers has claimed that 'hundreds of farmers' are abandoning their coffee crops daily to work on coca plantations (Taj, 2019). Delays in certifying organic coffee beans, which are more expensive for farmers to produce but also fetch higher prices, have also been suggested as a possible influence (Grisaffi & Farthing, 2021; Taj, 2019). The UNODC noted a link in one case between the price of gold and the price of coca: in San Gabán, Peru, where coca growing and illegal mining take place in the same area, a combination of enforcement activities and a drop in the price of gold led to the area occupied by coca more than doubling in 2015 (UNODC, 2016, p. 29).

2.3 North America (cannabis)

No evidence could be found regarding how climate change affects North American cannabis production through socioeconomic pathways in the time available to prepare this report. There is a substantial amount of evidence about the impacts of indoor and outdoor cannabis production on the environment, and some evidence about the potential biological impacts of climate change on cannabis production (discussed in section 3.1).

3 Biological impacts of climate change

Climate change is likely to have some limited effects on illicit crops on a biological level, but these effects are highly location-specific and growers have considerable ability to mitigate effects through crop breeding and changing agricultural practices. Cannabis, coca, and poppies are all hardy plants that are well-adapted to conditions of water scarcity. Like all domesticated crops, illicit crops have been bred to produce cultivated varieties that are particularly suited to a wide range of conditions. Different varieties of opium poppies, for example, are grown 'from Bombay (India) to Moscow (Russia) in the northern hemisphere and to Tasmania (Australia) in the southern hemisphere' (Gümüşçü & Gümüşçü, 2015, p. 79). Cannabis growers are confident that plant breeding programmes can produce varieties able to grow well under a very wide range of conditions (Schaneman, 2022). The coca bush is similarly 'a tough plant… that's likely to adapt to the expected changes' (Smith & The Daily Climate, 2014). Growers of all three of these crops are also likely to be able to adapt to a wide range of conditions by adjusting their agricultural practices, including use of irrigation, pesticides, and fertilisers (Smith & The Daily Climate, 2014).

3.1 Cannabis

Cannabis plants are well-adapted to projected changes in atmospheric CO_2 concentrations and to drought conditions. The concentration of CO_2 in the atmosphere has increased from about 280 parts per million (ppm) in the 18th century to the present level of 423 ppm, and is projected to reach as high as 700 ppm by the end of the twenty first century (Houghton et al. 1996, cited in Chandra et al., 2011, p. 291; NOAA, 2024). Elevated atmospheric CO_2 concentrations are associated with enhanced photosynthesis, growth, and water use efficiency in many (but not all) plant species (Chandra et al., 2011, pp. 292, 294). One study of cannabis plant growth under laboratory conditions found that raising the concentration of CO_2 from current atmospheric conditions to 700 ppm increased net photosynthesis by 38% to 48% and increased water use efficiency by 157% to 191% in four different varieties of cannabis plants; a CO_2 concentration of 545 ppm was also tested but did not produce a significant effect (Chandra et al., 2011, p. 291). Another study found that drought-stressed cannabis plants contained 12% to 13% higher concentrations of the major desired (for drug production) cannabinoid compounds, and produced 43% to 67% higher yields of cannabinoid compounds per unit of growing area, suggesting that drought stress could be beneficial for the purpose of drug production (Caplan et al., 2019).

Climate change is expected to produce varying effects in different areas across the USA and Canada, and commercial cannabis farmers anecdotally report increasing variability and uncertainty in growing conditions. The majority of the evidence found on this topic appears to consist of anecdotal reports in news media and cannabis industry publications, rather than high-quality peer-reviewed research. Cannabis growers on the west coast of the USA (Colorado, Oregon, California) report that conditions are generally becoming drier, with water shortages, heat waves, increased risk of wildfires, greater variation in precipitation amounts, and unusual and extreme weather events posing increasing risks to crops (Bossi, 2022; Williams, 2022). Wildfires pose not only a direct risk of burning crops, but also an indirect risk of crop damage from smoke or ash from nearby fires (Bossi, 2022; Dillis et al., 2023). In the northeastern USA, growers report shorter and warmer winters, less snow, more rain, more seasonal variation, and changes in pest and pathogens (Schaneman, 2022). No detailed analysis of impacts on crop yields or viability was found.

3.2 Coca

The Latin American coca belt is expected to become generally warmer and drier with local variations as a result of climate change, but this is not expected to have a significant effect on coca production. Average temperatures in the region may rise by up to 4 ºC by 2100, with areas closer to the equator receiving more rainfall and areas north and south of the equator receiving less (Smith & The Daily Climate, 2014). Coca is resistant to dry conditions because of a natural waxy layer on its leaves that protects it from water loss, and it is currently mostly grown in areas that receive three to four times as much rain as it needs, giving those areas a margin of safety (Smith & The Daily Climate, 2014). Warmer temperatures are unlikely to negatively affect coca plants, but might create some opportunities for expanding growing areas to higher elevations (Smith & The Daily Climate, 2014). Recent evidence about the impacts of climate change on coca production appears to

be scarce. A study in Bolivia found that variations in rainfall and temperature did not produce significant physiological responses in coca crops, but found that periods of dry weather are important for farmers to be able to dry the harvested leaves, so a decrease in rainfall is likely to contribute to larger marketable yields (McGlade et al., 1994). A report on climate change and security issues in Colombia described the impacts of climate change as 'unclear' but concluded that 'because the coca plant is well suited to much of Colombia's territory, the environmental changes alone do not seem likely to curb its production' (Catarious & Espach, 2009, p. 23). Another study[5] considering Colombia concluded that coca was not vulnerable to climate change, as it expected the climate to remain within favourable ranges for coca production, with slight regional variations around optimum growth temperatures, but that there was a risk of land and soil degradation which could cause yields to decrease by up to 40% without adaptation efforts (Lathrop-Melting, n.d.).

3.3 Poppies

Opium poppies are well-adapted to drought conditions, and there is limited evidence that projected changes in atmospheric CO_2 concentrations could increase the concentration of opiates produced. Opium poppies have been described as 'a low-risk crop in a high-risk environment' (Mansfield & Pain 2007, cited in Kienberger et al., 2017, p. 733), in the sense that it is a drought-resistant crop that stores well and is continually in high demand, but comes with the dangers of being illicit (Kienberger et al., 2017, p. 733). A laboratory study examined the effects of CO_2 on wild poppies (*Papaver setigerum*) at concentrations of 300, 400, 500, and 600 ppm, which correspond approximately to atmospheric conditions in the 1950s, the 2000s, and possibly around 2050 and 2090[6]. The study found that higher CO_2 concentrations produced significant increases in leaf area, above-ground biomass, and total alkaloid content (especially morphine) (Ziska et al., 2008).

Academic studies in Turkey anticipate little impact on the geographic range of poppy production within Turkey in the next fifty years, but poppy growing may become infeasible in some current growing areas after 2070. Poppies are grown commercially in Turkey for the pharmaceutical industry. One study used topographic map data and projections of temperature and rainfall from the Hadley Centre Global Environment Model version 2 (HadGEM-2ES) under a 'worst case' climate scenario[7] to forecast whether the climate in current poppy-growing provinces would continue to be suitable through the end of the current century. The study projected very small reductions in growing areas in the periods 2015-2040 and 2041-2070, but a significant reduction in the period 2071-2099, during which large portions of the four westernmost provinces where poppies are currently

[5] This research is described only in an abstract and some presentation slides which are available online (https://science.du.edu/research/showcase/will-climate-change-affect-cocaine-production); complete details of the research could not be found. I have attempted to contact the author and the publishing university to obtain more information, but no response was received within the time available to prepare this report.

[6] The climate scenario used to estimate when CO_2 concentrations of 500 and 600 ppm might be reached was not identified explicitly in the study, but is one of the scenarios developed for the IPCC's Second Assessment Report in 1995.

[7] The IPCC scenario RCP8.5, which assumes high fossil-fuel use and no climate mitigation policies.

grown would become unsuitable (Yıldırım et al., 2016). A second study in the western province of Usak suggested that warming temperatures will make it uneconomical to sow poppy crops in the spring; while poppies are mostly planted in the autumn, spring sowing can be used to replace or augment crops damaged in the winter, so if spring planting becomes uneconomical, this could potentially affect overall yields (Ayhan & Yildirim, 2021).

In Tasmania, Australia, there is some expectation that climate change could have a positive impact on poppy production. Poppies are commercially grown in Tasmania for the pharmaceutical industry. A local government agency reports that poppies currently grow well due to long daylight hours and a temperate climate with suitable temperatures, rainfall, and humidity ranges and a low risk of frost at key growth stages (Cradle Coast NRM, n.d., p. 1). The agency reports that climate change is expected to lead to generally warmer average temperatures (increases of 2.6 to 3.3 °C) and lower risk of frost, although the timeframe considered is not mentioned, leading to accelerated poppy development, increased alkaloid content, and a generally 'positive influence on poppy production' (Cradle Coast NRM, n.d., p. 1). Rainfall patterns are expected to change in different ways across the poppy-growing region, with increases or decreases of up to 20% in different seasons in different areas; the impact of these changes is described as being likely to 'make poppy management more challenging' (Cradle Coast NRM, n.d., p. 2).

No studies examining the impacts of climate change on the productivity or viability of poppy crops in Afghanistan could be found in the time available to prepare this report. Projections of the potential impacts of climate change on staple crops such as wheat, rice, and corn have been published (see for example Khalily, 2022), but no similar projections of impacts on poppy growing were found. Afghanistan experiences severe water scarcity challenges which are expected to worsen in the future due to climate change (UNODC, 2023a, p. 12), but poppy crops can tolerate significant water stress. One study spanning 1993-2013 identified drought, disease, frost, and flood as the most significant environmental shocks affecting opium poppy crops during that period, and shows fluctuating but broadly declining yields, but did not make any direct connection with climate change (Greenfield et al., 2015, pp. 13–14).

4 Emerging illicit drugs

Methamphetamine and fentanyl are having significant impacts on patterns of illicit drug production, but their emergence has been driven by market forces (changes in demand from drug users and changes in production costs and processes) rather than by climate change.

In Afghanistan, the manufacture of methamphetamine is growing and there is a possibility that this could incentivise poppy growers to change to cultivating ephedra to meet demand for the necessary inputs. The amount of methamphetamine seized in Afghanistan and neighbouring countries began increasing rapidly in 2017, from 2.5 tons in that year to 29.7 tons in 2021, and seizures within Afghanistan have risen from less than 100 kg in 2019 to nearly 2,700 kg in 2021 (UNODC, 2023d, pp. 6–7). 'The drastic increase in methamphetamine seizures in Afghanistan and neighbouring countries indicates that methamphetamine trafficking is expanding rapidly, changing illicit drug markets traditionally

focused on the trafficking of opiates from Afghanistan' (UNODC, 2023d, p. 6). The UNODC reports that methamphetamine manufacturing in Afghanistan uses common cold medications and industrial-grade bulk chemicals as inputs (UNODC, 2023a, p. 5), while other observers argue that the ephedra plant, which grows wild across Central Asia and is not regulated internationally, is a more economical source for the necessary chemicals (Mansfield, 2023a, 2023c). At present, ephedra harvesting is concentrated primarily in provinces without much poppy cultivation and relies on collecting wild plants (Greenfield et al., 2021, p. 13), but sustained demand for methamphetamine could lead to a decrease in demand for opium poppies and potentially create incentives for growing ephedra. It is uncertain whether Afghanistan could compete in synthetic drug manufacturing against better-established illegal drug industries in China, Southeast Asia, and India, but production on a small scale could be feasible (Greenfield et al., 2021, p. 13).

Fentanyl is displacing heroin in North America because of its low cost and high strength, and this shift in demand is having significant impacts on opium producers in Mexico. Fentanyl can be made in laboratories 'from cheap chemicals in relatively low-cost, quick-turnaround operations, with minimal but specialized labor requirements and low visibility' (Greenfield et al., 2021, p. 7). It is highly concentrated, easy to transport, cheap to manufacture, avoids the risk and expense of growing poppies in the open and transporting materials around the world, and is so potent that 'by some estimates, the wholesale price of fentanyl adjusted for potency is perhaps 1 percent that of heroin' (Grandmaison et al., 2019, pp. 9–10; Greenfield et al., 2021, p. 7). In the USA, Fentanyl has been taking market share from heroin, and 90% of the heroin consumed in the USA comes from Mexico (Grandmaison et al., 2019, p. 11), so this has depressed prices paid to Mexican poppy growers by as much as 50% to 80% (Grandmaison et al., 2019, pp. 18, 23) and significantly changed the cost-benefit analysis for poppy growers (Grandmaison et al., 2019, p. 26). A study of three villages in poppy-growing areas showed declines in the areas of cultivated land immediately after the poppy price collapsed in 2017-2018 (Tamariz et al., 2023, p. 189). In one village, which was geographically isolated and had high levels of poverty, farmers returned to growing maize and other subsistence food crops; a second village showed some experimentation with alternative livelihoods and significant migration to the state capital city; and in the third village there was significant migration to the USA, supported by existing networks that had historically facilitated migration (Tamariz et al., 2023, pp. 197–201). Since 2021, large-scale clandestine fentanyl laboratories have been found in Mexico demonstrating 'massive' local production (Tamariz et al., 2023, p. 189).

5 Migration

Climate change is recognised as a driver of migration, but there is little evidence linking climate-induced migration with changes in patterns of illicit drug production. Migration (which mostly takes place within countries but can also be cross-border) is a common practice for livelihood diversification, food security, and coping with environmental shocks including droughts, floods, and high temperatures, which are associated with climate change (Masters 2019, cited in Abdenur & Rüttinger, 2020, p. 11; Huber et al., 2023, pp. 6–7; IISS, 2019, pp. 38, 42). When examples of migration are discussed in the literature on illicit drug production, however, the forces driving migration are generally factors other than

climate change, and the effects on drug production are limited. For example, in Afghanistan in 2008, poppy growers moved from the central fertile areas of Helmand province into desert areas, with labour migration following the poppy industry because it was more labour-intensive than the agricultural operations that were left behind. However, this movement was driven by improvements in well-drilling technology, poppy eradication programmes, and land prices, not by climate change (Greenfield et al., 2015, pp. 18, 21–24) (this case is also mentioned in section 2.1 of this report). In Bolivia, the collapse of the tin mining industry induced former miners to migrate to Chapare and begin farming coca (Smith & The Daily Climate, 2014) (see also section 2.2). In Peru, a slump in world coffee prices induced coffee growers to migrate to coca-growing areas of the country (Grisaffi & Farthing, 2021; Taj, 2019) (section 2.2). In Mexico, one study found that increased price competition and the abolition of agricultural subsidies drove farmers to migrate to cities or to the USA, with non-migrating farmers becoming involved in illicit crops (Grandmaison et al., 2019, p. 6) (section 2.2), while another study found that changes in drug consumers' preferences in the USA led to the collapse of the poppy industry and significant out-migration in some villages (Tamariz et al., 2023) (section **Error! Reference source not found.**).

6 Gender

Limited evidence suggests that illicit drug production can offer livelihood alternatives for women, but does not make a link to the impacts of climate change. In Afghanistan, women cultivate poppy on their own land or work for others, and the income that they receive has been linked to a decline in rural indebtedness, improvements in women's status in the community, improvements in their standard of living, and development of alternative legal livelihoods (NUPI & SIPRI, 2022, p. 3; Parenti, 2015, p. 195). In the Chapare region of Bolivia, women cultivate, fertilise, harvest, and transport coca leaves (Farthing & Grisaffi, 2023, p. 4), which can be done 'within or relatively nearby the homestead, allowing women to still fulfil household duties at the same time'; in this way, coca growing supports women's freedom of movement and economic independence (Gumucio, 2015, p. 6).

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