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with careful definitions of terminology and concepts along with presentation of the increasingly strong evidence that validates growing concern about climate change and its probable consequences. Section “Uncertainties and Moral Obligations Despite Them” addresses the kinds of uncertainty at issue when it comes to climate science. The fact that there are uncertainties involved in the understanding of climate change will be shown to be consistent with there being moral obligations to address climate change, obligations that include expanding the knowledge of the subject, developing plans for a variety of possible adaptation needs, and studying further the various options for mitigation and their myriad costs. Section “Traditions and New Developments in Environmental Ethics” covers a number of moral considerations for climate change mitigation, opening with an examination of the traditional approaches to environmental ethics, then presenting three pressing areas of concern for mitigation efforts: differential levels of responsibility for action that effects the whole globe; the dangers of causing greater harm than is resolved; and the motivating force of diminishing and increasingly expensive fossil fuels that will necessitate and likely speed up innovation in energy production and consumption that will be required for human beings to survive once fossil fuels are exhausted.

9 Ethics and Environmental Policy

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55 once fossil fuels are exhausted.

56 Introduction

57 Few subjects are as complex and as frequently oversimplified as climate change. After big
58 snowfalls in winters past, news outlets have featured various observers of these local
59 events, who dismiss the idea of global warming with statements such as, “So much for
60 the global warming theory” [1]. On the other hand, climate scientists note that Earth’s
61 average temperature has risen over time, and as a result, they predict increases in
62 temperature extremes and vaporization of water that, in turn, lead to an expectation of
63 increased snowfall in some years. Problems of understanding and misunderstanding such
64 as these are important causes of confusion in discussions about climate change, and those
65 problems and that confusion combine with the complexity of the issues at stake to add
66 considerable challenge to addressing the topic of focus in this chapter: the ethics of climate
67 change mitigation.

68 This chapter will argue that despite limitations to knowledge about the complexities of
69 the climate system, certain efforts must be undertaken to prepare for and address the
70 developments in climate change. The science on the subject is growing increasingly

71 compelling, showing that there is need to work toward mitigating the causal forces that are
72 bringing about climate change along with preparing adaptations to changes in climate,
73 some of which have already begun [2]. Furthermore, the existence of uncertainties with
74 respect to climate science calls for more study of the subject of climate change, with greater
75 collaboration than is already at work. Calling for further study of the subject, however,
76 does not imply the postponement of all or any particular measure of precaution and
77 potential action. This chapter will examine the current knowledge about climate change as
78 well as the moral dimensions at issue in both seeking to minimize those changes and
79 working to prepare for the changes and their effects.

80 When the term “mitigation” arises in this chapter, it is important to keep in mind
81 a consistent meaning. To mitigate something generally means to make it less harsh and less
82 severe, but in relation to climate change, mitigation carries a more precise meaning. The
83 term refers to human actions taken to reduce the forces that are believed responsible for
84 increase of the average temperature of Earth. The primary concern with climate change is
85 the increase of global average temperature, and mitigation is aimed at decreasing the rate
86 of growth of this global temperature and stabilizing it or even decreasing it should it rise
87 too high. Mitigation is sometimes referred to as abatement. Generally, the idea of
88 abatement is to reduce either the rate of growth that is or will likely be problematic, or
89 to actually reverse the trend and reduce global average temperature. In contrast to
90 mitigation, a second category of response to climate change is to find ways of adapting
91 life to new conditions, the method of adaptation. Adaptation refers to adjustments made
92 in response to changing climates that moderate harm or exploit beneficial opportunities
93 [3]. The interesting issue that arises in focusing on climate change mitigation – the efforts
94 to decrease the causal forces of rising global temperatures – is that subtle changes in
95 temperature might be the kind to which some or even many people will be able to adapt
96 relatively easily. For instance, if people live on coastal lands that are increasingly inun-
97 dated, there are ways of reclaiming land from water or places to which people can move in
98 adaptation to the climate changes. Other adaptations might include systems of planned
99 agricultural crop changes prepared to avoid problems that could arise in growing food for
100 the world’s increasing population. An important consideration about adaptation is that
101 while humans may be able to change and adjust to changing climates, natural ecosystems
102 and habitats may not, a point that will also be addressed in this chapter.

103 There are certainly reasons to worry about sudden, great changes, but more gradual
104 and less severe changes raise a host of ethical issues. For instance, it is reasonable to ask
105 whether a farmer has the moral right to grow a certain crop. If so, then it may be that
106 people have a responsibility to avoid changing the climate. Belief in such a right, however,
107 could be considered highly controversial. What if farmers could reasonably expect some
108 help in adapting the crops that they raise to new conditions? This idea would lessen the
109 moral concern over the ability to grow a certain crop in a particular region, and thus
110 a matter of adaptation would have bearing on the moral dimensions of climate change
111 mitigation.

112 It is likely that the best solution to address the ill effects of climate change will require
113 a combination of mitigation and adaptation strategies. A central claim of this chapter,

114 therefore, is that the ethics of climate change mitigation must not be considered in
115 isolation from the options available for adaptation. Of the two, however, the more
116 controversial, morally speaking, are abatement efforts, or mitigation. This is because
117 when climate conditions change, there will be no choice for people but to adapt to new
118 circumstances if presented with serious challenges for survival, at least until humans are
119 able to exert control in a desirable way on the trends in global climate. But abatement
120 efforts, on the other hand, require sacrifices early, before certainty exists about the exact
121 nature and extent of the problems to come and whom the problems, benefits, and
122 mitigating efforts will most affect, and how.

123 Accompanying the problem of complexity that exists in climate change is a necessary
124 challenge of uncertainty. The approach of addressing change through adaptive measures
125 can be started early, and is also possible as some more gradual changes occur, such as in the
126 evacuation of islands that slowly disappear under the rising level of the sea. Other
127 problems, however, are predicted to occur swiftly, such as in the potential disruption of
128 the Ocean Conveyor, a “major threshold phenomenon” that could bring “significant
129 climatic consequences,” such as severe droughts ([4], pp. 562–563). The problem of
130 knowledge, of the limits to human abilities to identify where suffering or benefits will
131 occur, under what form, by which mechanisms, implies that preventive adaptations may
132 be impossible in the face of sudden changes in global climates. Furthermore, if there
133 existed no idea of changes that might occur, this limited knowledge might render the
134 effects of changing conditions less troubling morally speaking. But the fact is that today
135 many scientists have devised models that suggest potential outcomes of climate change
136 and so undercut the option of ignorant dismissal or avoidance of moral obligation.
137 Limited knowledge about climate change first and foremost calls for increasing the
138 knowledge and study of the subject, but it also demands consideration of the kinds of
139 problems that can be expected, weighed against the anticipated costs of alleviating the
140 worst of the threats.

141 This chapter will offer a survey of a number of important factors for the consideration
142 of the moral obligations involved in confronting the challenges of climate change. The first
143 step is to identify as carefully as possible what is known about climate change science,
144 predictions, concerns, models, and both mitigation and adaptation efforts. While the
145 present volume is focused primarily on the mitigation side of reactions to climate change,
146 these mitigation efforts ought to be planned in part with reference to what options and
147 actions are available, likely, and desirable for adaptation. ➤ Section “Understanding
148 Climate Change,” therefore, provides an overview of current understanding of climate
149 change with careful definitions of terminology and concepts along with presentation of
150 the increasingly strong evidence that validates growing concern about climate change and
151 its probable consequences. Next, ➤ section “Uncertainties and Moral Obligations Despite
152 Them” will address the kinds of uncertainty at issue when it comes to climate science. The
153 fact that there are uncertainties involved in human understanding of climate change will
154 be shown to be consistent with there being moral obligations to address climate change.
155 As mentioned above, these are obligations to know more than is currently known, to
156 develop plans for a variety of possible adaptation needs, and to study further the various

157 options for mitigation and their myriad costs. Plus, Gardiner [4] presented a convincing
158 case for the weighing of options that concludes in accepting the consequences of a small
159 decrease in GNP from setting limits on global greenhouse gas emissions. Gardiner's
160 argument is compelling even in the face of uncertainty. After all, the uncertainties involved
161 in climate change resemble uncertainties that motivate moral precaution in so many other
162 spheres of human conduct. Finally, section "Traditions and New Developments in
163 Environmental Ethics" covers a number of moral considerations for climate change
164 mitigation. This section opens with an examination of the traditional approaches to
165 environmental ethics, then presents three pressing areas of concern for mitigation efforts:
166 differential levels of responsibility for action that effects the whole globe; the dangers of
167 causing greater harm than is resolved (with geoengineering efforts among others); and the
168 motivating forces of diminishing and increasingly expensive fossil fuels that will necessi-
169 tate and likely speed up innovation in energy production and consumption that will be
170 required for human beings to survive once fossil fuels are exhausted.

Understanding Climate Change

171
172 Given the complexity of addressing global climate change, it is crucial to clarify the
173 meaning of a number of key terms, forces, and strategies for mitigation, so this first
174 section will begin with a description of central terms and concepts at issue. The section
175 then covers perceptions and methods for describing climate change because ideologies
176 and affective influences on discourse about climate change can be used to mislead the
177 public about the nature and the state of climate science. After that, the section examines
178 the state of scientific knowledge and the predictions that the scientific community has
179 presented about the future of climate change. This is important in order to grasp the
180 extent of concern that world leaders and publics ought to feel about the future of the
181 world's climates. Finally, this section will close with a brief description of the various
182 proposals that have been considered for mitigating climate change.

Terminology and Concepts

183
184 Uncertainty, confusion, and misunderstanding result from poorly or ambiguously defined
185 terminology and concepts, and this is especially the case with the topic of climate change.
186 Climate change is complex and often elicits heated and impassioned public discourse. To
187 reduce such problems, this section provides definitions for terms and concepts that are
188 essential for both an explanation of what is known about climate change and for
189 consideration of the broader topic of ethics and climate change mitigation. Some of
190 these definitions are contested, and in such cases, the preferred definitions presented here
191 will be contrasted with other definitions found in the literature, along with provision of an
192 explanation for the selections made.

193 Weather and Climate

194 The term “weather” refers to short-term atmospheric conditions occurring in a specific
195 time and place and identified by the sum of selected defining variables that can include
196 temperature, precipitation, humidity, cloudiness, air pressure, wind (velocity and direc-
197 tion), storminess, and more. Weather is measured and reported at the scale of moments,
198 hours, days, and weeks. Climate, on the other hand, is defined (in a narrow sense) as the
199 aggregate of day-to-day weather conditions that have been averaged over longer periods of
200 time such as a month, a season, a year, decades, or thousands to millions of years. Climate
201 is a statistical description that includes not just the average or mean values of the relevant
202 variables but also the variability of those values and the extremes [5, 6].

203 The Climate System

204 Understanding climate entails more than consideration of just the aggregated day-to-day
205 weather conditions averaged over longer periods of time. Those average atmospheric
206 conditions operate within the wider context of what is called the climate system that
207 includes not just the atmosphere but also the hydrosphere, the cryosphere, the Earth’s land
208 surface, and the biosphere.

- 209 ● The *atmosphere* is a mixture of gasses that lie in a relatively thin envelope that
210 surrounds the Earth and is held in place by gravity. The atmosphere also contains
211 suspended liquid and solid particles that “can vary considerably in type and concen-
212 tration and from time to time and place to place” ([7], p. 37). On average, 50% of the
213 atmospheric mass lies between seal level and 5.6 km (3.48 miles or 18,372 ft) of
214 altitude. To highlight how thin this is, consider that the peak of Mt. McKinley in
215 Alaska is 6.19 km (20,320 ft) above sea level, and as a result, the density of air is less
216 than 50% of that available at sea level, or that the peak of Mt. Everest at 8.85 km
217 (29,029 ft) has less than 32% of the air density that is available at sea level. Commercial
218 jet airliners generally fly at about 10.5 km (35,000 ft) above sea level, and humans
219 would lapse into unconsciousness very quickly if cabin pressure were to decrease
220 suddenly at this altitude [8].
- 221 ● The *hydrosphere* consists of liquid surface water such as the ocean, seas, lakes, and
222 rivers, along with groundwater, soil water, and importantly, water vapor in the
223 atmosphere.
- 224 ● The *cryosphere* consists of all snow, ice (glaciers and ice sheets), and frozen ground
225 (including permafrost) that lie on and beneath the surface of the Earth.
- 226 ● Earth’s *land surface* consists of the naturally occurring rock and soil along with the
227 structures (buildings, roads, etc.) that humans have constructed.
- 228 ● The *biosphere* consists of all living organisms, both plant and animal, on land, in fresh
229 water, and in the ocean, including derived dead organic matter such as litter, soil
230 organic matter, and ocean detritus.

231 The climate system functions by means of complex interactions among these five
232 components in which flows and fluxes of energy and matter take place through myriad
233 processes such as radiation, convection, evaporation, transpiration, chemical exchanges,
234 and many more [9]. Given this complexity, climate science is an interdisciplinary
235 endeavor that necessarily involves the interactions and contributions of a wide range of
236 the physical sciences such as physics, chemistry, biology, ecology, oceanography, as well as
237 the atmospheric sciences. Moreover, because human existence involves interactions with
238 climate, the social sciences such as psychology, political science, and sociology also play
239 important roles in human understanding. In addition, climate operates over time and
240 space, so the synthesizing disciplines of history and geography have much to contribute as
241 well. Furthermore, as shown later in this chapter, the humanities contribute to the
242 understanding of the social dimensions of climate systems when it comes to considering
243 the moral implications of various situations and actions in response to climate change.

244 **Climate Change**

245 The most recent definition of climate change developed by the Intergovernmental Panel
246 on Climate Change (IPCC) will be used in this chapter:

- 247 ▶ Climate change refers to a change in the state of the climate that can be identified (e.g., by
248 using statistical tests) by changes in the mean and/or the variability of its properties, and
249 that persists for an extended period, typically decades or longer ([9], p. 78; see also [10]).

250 Importantly, this definition is solely descriptive and includes no reference to causa-
251 tion, particularly no indication of the extent to which any changes in climate result from
252 natural or human (anthropogenic) causes. Other definitions of climate change include
253 causation, such as the United Nations Framework Convention on Climate Change:

- 254 ▶ “Climate change” means a change of climate which is attributed directly or indirectly to
255 human activity that alters the composition of the global atmosphere and which is in
256 addition to natural climate variability observed over comparable time periods ([11], p. 3).

257 The first definition was selected for use in this chapter because it focuses on identifying
258 and describing observed changes in climate and specifically refrains from assigning causa-
259 tion to either natural or anthropogenic processes. As a result, it draws attention to the
260 distinction between two aspects of inquiry: (1) questions related to the presence, extent, and
261 direction of changes in climate, and (2) questions about causation of any observed changes,
262 especially, determinations of natural or anthropogenic causes. Views about (2) are often
263 disconnected from questions about presence, extent, and direction of change and also tend
264 to generate more contentious debate, especially in public and political discourse. As means
265 to reduce contention, it is helpful to make the clear distinction between these two aspects of
266 inquiry, and such clarity is especially important in this chapter, considering issues of ethics,
267 mitigation, and adaptation. Additionally, and importantly, the selected definition implies
268 no specific type of change(s) but instead fosters recognition that changes can occur in all


269 manner of the variables that constitute climate such as temperature, precipitation, humidity,
270 cloud cover, etc. (this point is further elaborated below with respect to the term “climate
271 change” and “global warming”).

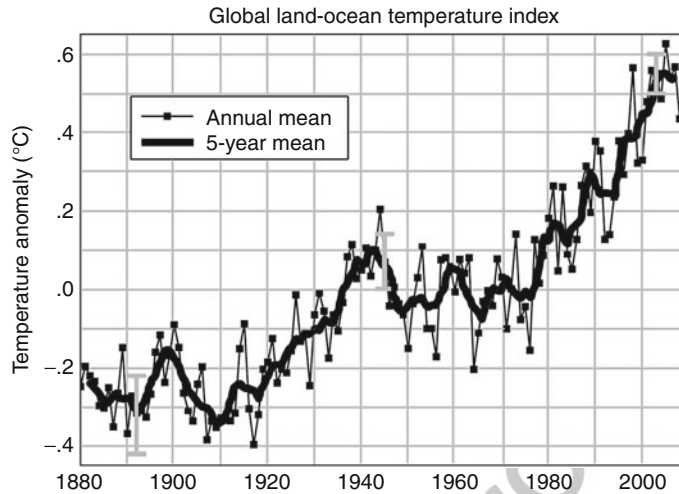
272 An additional reason to clarify the difference between (1) and (2) is that consideration
273 of (1) generally engenders less controversy, while the task of determining who should act
274 in addressing any needs that arise from climate change will depend in part on how one
275 addresses issue (2). As such, (2) is not to be ignored in addressing the ethics of climate
276 change, but after untangling (1) from (2), the problems to be addressed can be recognized
277 for what they are more easily.

278 **Climate Variability**

279 Most definitions of climate variability found in the literature differ little from the above
280 definitions of climate change. For example, as defined in the Synthesis Report for the
281 IPCC Fourth Assessment ([9], pp. 78–79), the two terms actually seem synonymous in
282 that they both refer to changes occurring on time scales of multiple decades or longer and
283 they both allow for natural and anthropogenic causes. Other definitions of climate
284 variability retain the focus on time scales of multiple decades or longer but limit climate
285 variability to only natural causes [12, 13]. In this chapter, however, the term will refer to
286 something different from either of these uses.

287 The term “climate variability” is used in this chapter in recognition that the long-term,
288 statistical averages of the variables that define climates can contain substantial variation
289 around the mean. Droughts, rainy periods, El Niño events, etc., occur in time periods of
290 a year to as much as 3 decades within climates that are considered to be stable as well as
291 within climates that are experiencing changes in the longer term. This variability is
292 different from extreme weather events such as floods and heat waves that occur on time
293 scales of hours, days, and weeks, and it is also different from the long-term climate changes
294 that occur on scales that span multiple decades to millions of years (which have already
295 been defined above as “climate change”).

296 The reasons to differentiate climate variability from climate change in this way are
297 twofold. First, climate variability can generate considerable “noise” in the data that can
298 lead to erroneous conclusions about climate change. For example,  *Fig. 9.1* shows two
299 levels of variability – interannual and multi-decadal – that are present in the observed global
300 temperature record that extends from 1880 to 2009. Inter-annual variability (variability from
301 year to year) is as much as 0.3°C (0.54°F), a range that could be expressed as 1 year with a very
302 hot summer and a mild winter followed by a second year with a mild summer and a very cold
303 winter. The conditions present in either of these years could lead people to make poor
304 judgments about climate. In particular, the long-term warming trend that the graph shows
305 occurring across the full 119 year period is sometimes dismissed because people generally give
306 greater weight in decision making and opinion formation to immediate affective sensory
307 input over cognitive consideration of statistics [14] (more will be said below about human
308 decision making that is affect-based compared to a basis on statistical description). The





■ Fig. 9.1

A line plot of the global land-ocean temperature index from 1880 to 2009, with the base period 1951–1980. The dotted black line is the annual mean and the solid black line is the 5-year mean. The grey bars show uncertainty estimates [16]


309 variability over several decades is exhibited in Fig. 9.1 for the time period 1940–1980,
310 which shows a plateau within the longer term, 119-year warming trend. During this shorter
311 time period, media reports and even a few researchers erroneously forecast “global cooling”
312 based on the observational record at the time that included inadequate and uncertain data
313 from years earlier than this time period and, obviously, no data beyond 1980 ([15], p. 85).

314 The second important reason for distinguishing between climate variability and climate
315 change in the way defined in this chapter is related to dynamic equilibrium in ecosystems.
316 Dynamic equilibrium results as ecosystems adapt to dynamic, ongoing forces that are not so
317 extreme as to produce catastrophic changes. This dynamic equilibrium occurs because the
318 change forces are not dramatic enough (or they cancel each other out), so that relative
319 stability in the ecosystem can be perpetuated as the organisms (plants and animals) and the
320 physical environment respond with adjustments that are within their adaptive capacities. In
321 general, ecosystem adaptive capacity is not exceeded (and dynamic equilibrium is
322 maintained) as a result of climate variability as defined here, but climate change, on the
323 other hand, often exceeds this capacity and leads to fundamental alterations of the ecosys-
324 tems. Such fundamental alterations occurring in natural ecosystems include processes such
325 as species extinction, changes in community compositions, changes in ecological interac-
326 tions, changes in geographical distributions, etc. Fundamental alterations can also occur
327 within ecosystems upon which humans depend, leading to such changes as increases/
328 decreases in agricultural productivity and the availability of water, changes in storm pat-
329 terns, etc. [3]. These effects on both natural and human ecosystems will be discussed in
330 more detail in what follows, but the important point here is that climate variability rarely
331 produces such fundamental alterations whereas climate change frequently can.

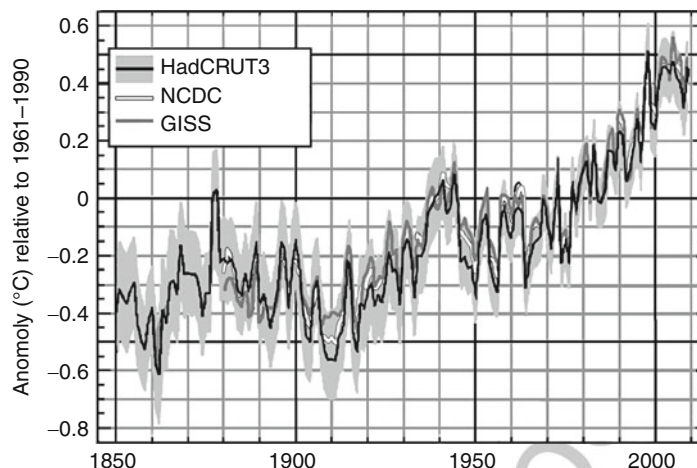
332 **Global Warming and Global Average Temperature**

333 Global warming is defined as an increase in the average temperature of Earth's surface
334 [17]. As  *Fig. 9.1* illustrates, this average surface temperature has increased by $0.75^{\circ}\text{C} \pm$
335 0.3°C ($1.35^{\circ}\text{F} \pm 0.54^{\circ}\text{F}$) between 1880 and 2009. While this change might seem small, the
336 paleo-climate record demonstrates that even “mild heating can have dramatic conse-
337 quences” such as advancing or retreating glaciers, sea level changes, and changes in precip-
338 itation patterns that can all force considerable changes in human activity and push natural
339 ecosystems beyond dynamic equilibrium [18]. The graph in  *Fig. 9.1* comes from NASA's
340 Goddard Institute for Space Studies Surface Temperature Analysis (GISTEMP) database
341 which contains temperature observations from land and sea from 1880 to the present [19].
342 It is one of three such large databases of Earth surface atmospheric observations that all
343 begin in the mid-to-late nineteenth century and extend to the present. The National
344 Oceanic and Atmospheric Administration (NOAA) maintains the second database that is
345 titled the Global Historical Climatology Network (GHCN), and while this database
346 contains observations from land stations only, it includes precipitation and air pressure
347 data as well as temperature [20]. The third database is abbreviated HadCRUT3 which
348 reflects the source of the dataset being a collaborative project of the Met Office Hadley
349 Center of the UK National Weather Service (“Had”) and the Climate Research Unit
350 (“CRU”) at the University of East Anglia. The Hadley Center provides marine surface
351 temperature data and the Climate Research Unit provides the land surface temperature
352 data. These three databases are not completely independent because they share some of the
353 same observation stations, but nevertheless, some differences in the raw data exist, and the
354 three centers work independently using different approaches to the compilation and analysis
355 done on the datasets. As such, the comparisons of results from the different databases allow
356 for verification. Considerable consistency is apparent across the databases, especially in the
357 overall trend of global warming since 1880. The different centers

358 ▶ ...work independently and use different methods in the way they collect and process data to
359 calculate the global-average temperature. Despite this, the results of each are similar from
360 month to month and year to year, and there is definite agreement on temperature trends from
361 decade to decade. Most importantly, they all agree global-average temperature has increased
362 over the past century and this warming has been particularly rapid since the 1970s [21].

363  *Figure 9.2* shows the temperature record for each of the three datasets superimposed
364 upon one another, and the consistency among them is clear. In addition, research has been
365 done to identify and quantify uncertainty in the data, and good estimates of the uncer-
366 tainty indicate that the data are valid. As one such study stated:

367 ▶ Since the mid twentieth century, the uncertainties in global and hemispheric mean tem-
368 peratures are small, and the temperature increase greatly exceeds its uncertainty. In earlier
369 periods the uncertainties are larger, but the temperature increase over the twentieth
370 century is still significantly larger than its uncertainty ([22], p. 1).



■ Fig. 9.2
Correlation between the three global average temperature records. All three datasets show clear correlation and a marked warming trend, particularly over the past 3 decades. The *HadCRUT3* graph shows uncertainty bands which tighten up considerably after 1945 [23]

371 The temperature records shown in ► Fig. 9.2 for each of the three centers are
372 developed as each center uses its dataset to calculate a “global average temperature,”
373 both for the past and for monthly updates, and it is these values that are displayed on the
374 graphs in the figure. While these calculations are done differently at the three centers, all
375 three use the following general procedure. First, they expend considerable efforts to
376 obtain the most accurate data possible and define the uncertainty that remains in those
377 data. Then, the monthly average temperature value for each reporting station is
378 converted into what is called an “anomaly.” The anomaly of each reporting station is
379 calculated by subtracting the monthly average value from the average value that the
380 station has maintained over some relatively long-term “base period” (For example, the
381 HadCRUT3 uses the period 1961–1990 as its base period). The reason for using anom-
382 alies is stated as follows:

383 ► For example, if the 1961–1990 average September temperature for Edinburg in Scotland
384 is 12°C and the recorded average temperature for that month in 2009 is 13°C, the
385 difference of 1°C is the anomaly and this would be used in the calculation of the global
386 average.

387

388 ► One of the main reasons for using anomalies is that they remain fairly constant over
389 large areas. So, for example, an anomaly in Edinburgh is likely to be the same as the

390 anomaly further north in Fort William and at the top of Ben Nevis, the UK's highest mountain.
391 This is even though there may be large differences in absolute temperature at each of these
392 locations.

393

394 ► The anomaly method also helps to avoid biases. For example, if actual temperatures were
395 used and information from an Arctic observation station was missing for that month, it
396 would mean the global temperature record would seem warmer. Using anomalies means
397 missing data such as this will not bias the temperature record ([21], see [24] for additional
398 explanation of the calculation and use of anomalies as used for the National Climate Data
399 Center's GHCN system).

400 Even though using anomalies produces the most accurate record of Earth's global
401 average temperature, it is still interesting to calculate one single absolute "global average
402 temperature." Using the GHCN dataset [25], the average value for the last 10 years, the
403 warmest decade on record [16, 26, 27], produces a global average temperature for planet
404 Earth of 14.4°C or 58°F.

405 **Climate Forcing and Climate Feedback**

406 Climate forcing refers to the processes that produce changes in the climate. The word force
407 is generally defined as "strength or energy that is exerted or brought to bear [and that
408 often] causes motion or change" [28]. With respect to Earth's climate system, a variety of
409 forces cause climates to change. These are called "climate forcings," and they are all related
410 to Earth's "energy balance," that is, the balance between incoming energy from the Sun
411 and outgoing energy from the Earth. The forcings can be internal or external. "Internal
412 forcings" occur within the climate system and include processes such as changes in
413 atmospheric composition or changes in ice cover that causes different rates of absorp-
414 tion/reflection of solar radiation. "External forcings" originate from outside the climate
415 system and include processes such as changes in Earth's orbit around the sun and volcanic
416 eruptions. Forcings can be naturally occurring, such as those resulting from solar activity
417 or volcanic eruptions, or anthropogenic in origin, for example, the emission of green-
418 house gases or deforestation ([3], p. 9).

419 A feedback is defined as a change that occurs within the climate system in response to
420 a forcing mechanism. A feedback is called "positive" when it augments or intensifies the
421 effects of the forcing mechanism or "negative" when it diminishes or reduces the effects
422 caused by that original forcing mechanism ([3], p. 875).

423 Forcing and feedback mechanisms often interact in complex ways that make it difficult
424 to decipher the processes and dynamics of climate change. This difficulty also frequently
425 frustrates policymakers, the media, and the public, and it can result in the dissemination
426 of misinformation, both intentional and unintentional, into the public discourse. One
427 example of this relates to the relationship between carbon dioxide (CO₂) and temperature.
428 While it is relatively easy to understand that increasing concentrations of atmospheric

429 CO₂ can increase the naturally occurring Greenhouse Effect thereby causing global
430 warming, confusion and misinformation result when research brings to light a climate
431 record in which changes in the atmospheric CO₂ level lag behind changes in temperature
432 by 800–1,000 years. The legitimate question arises as to how it could be possible that CO₂
433 causes global warming if the rise in temperature occurs before the increase in the
434 atmospheric concentration of CO₂. While the question is legitimate, unfortunately,
435 some who are disposed to doubt claims of global warming neither seek answers to the
436 question or pursue additional investigation. Instead, they simply assert the premise that
437 because CO₂ lags temperature it cannot possibly be the cause of global warming. However,
438 a more objective review of the scientific literature emphasizes the importance of
439 distinguishing between forcings and feedbacks.

440 The initial, external forcing that begins the temperature changes observed in the
441 climate record stems from fluctuations in the orbital relations between the Sun and
442 Earth, and these fluctuations produce rather small changes in the amount of solar
443 radiation reaching Earth [29]. This relatively weak forcing action causes small tempera-
444 ture changes that are then amplified by other processes [30]. One such amplifying process
445 that appears to be quite significant occurs because ocean temperature changes also change
446 the ocean's capacity to retain soluble CO₂. As this capacity changes, it causes CO₂ to either
447 be released from the oceans into the atmosphere (during times of warming temperatures)
448 or removed from the atmosphere and dissolved into the oceans (during times of cooling
449 temperatures). Consequently, CO₂ operates in these situations as a *positive feedback*
450 mechanism that augments the temperature change. In other words, it enhances the
451 Greenhouse Effect and amplifies temperature increases during times of warming and
452 reduces the Greenhouse Effect and reinforces temperature decreases during times of
453 cooling [31]. Careful analysis therefore suggests that a climate record which shows CO₂
454 operating as a feedback mechanism neither negates nor renders less likely the potential
455 that CO₂ could operate as an initial forcing mechanism as well. Considering that the
456 atmospheric concentration of CO₂ has increased by 25% in the last 50 years [32], it is
457 entirely possible that this increasing CO₂ concentration is functioning as the forcing agent
458 for contemporary global warming. Simply put, it is a false premise to claim that CO₂ could
459 not be causing contemporary global warming because CO₂ has been observed to lag
460 behind temperature changes in the past. This false premise has been lampooned by the
461 analogous statement that, "Chickens do not lay eggs, because they have been observed to
462 hatch from them" [33].

463 **Global Warming Versus Climate Change**

464 The terms "global warming" and "climate change" have been defined above and those
465 definitions will not be repeated here. But it is important to emphasize the difference
466 between the two terms and the significance of exercising precision in use of them. While
467 "global warming" is a useful way to refer to the increase of global average temperature that
468 strong scientific evidence shows has occurred over the last 130 years (● Fig. 9.2), for some

469 people, the term carries the automatic connotation that human activity is the cause of
470 this observed temperature increase. As stated earlier, a clear distinction should be made
471 between questions that, on the one hand, relate to the changes in climate, if any, that are
472 occurring, and on the other hand, the causes of any identified changes, specifically, naturally
473 occurring or anthropogenic. Because the term “global warming” carries the more polemical
474 and politicized connotation, it poses a higher probability of conflating the two questions
475 than does the term “climate change” which has not yet attracted such politicized interpretations.
476 Consequently, in general, the term “climate change” is preferable.

477 A second deficiency with the term “global warming” is the one dimensional and
478 totalizing change that it implies. Although the average temperature of planet Earth is
479 increasing, the temperature change that any particular place on the Earth might experience
480 could be cooling instead of warming, or perhaps, might be experiencing no change in
481 temperature at all. But the term “global warming” is easily, and perhaps most naturally,
482 understood to mean that all places on the Earth will experience warming. Moreover, even
483 if the term is explained, it does not readily lend itself to the broader understanding that
484 although the global average temperature is increasing, it is not necessarily the case that
485 temperature is increasing at any given place on Earth. The term “climate change,” on the
486 other hand, does not imply this uniform nature of change and thus possesses greater
487 capacity to communicate the potential for different changes occurring in different places
488 and regions. In addition, the term “global warming” implies a narrow view of the nature of
489 changes that can occur in the climate system, namely, an exclusive focus on temperature.
490 But the possible changes to climate are not restricted to just the climate variable of
491 temperature, and the observed increase in global average temperature has been associated
492 with changes in a range of other climate variables that include precipitation amounts,
493 timing, and patterns, cloudiness, humidity, wind direction and velocity, storminess, and
494 more. While the term “global warming” places the focus on temperature, the term
495 “climate change” offers a much richer capacity to incorporate these other types of changes
496 as well, and as a result, is generally emerging as the preferred term.

497 **Thresholds and Tipping Points**

498 The term “threshold” in ecology and environmental science means “a fixed value at which
499 an abrupt change in the behavior of a system is observed” ([34], p. 450). In climate
500 science, the term “climate threshold” means the point at which some forcing of the climate
501 system “triggers a significant climatic or environmental event which is considered unal-
502 terable, or recoverable only on very long time-scales, such as widespread bleaching of
503 corals or a collapse of oceanic circulation systems” ([3], p. 872). Substantial research
504 indicates that climate changes are prone to such thresholds, or “tipping points,” at which
505 climate on a global scale or climates at regional scales can suddenly experience major
506 change [35, 36]. A wide number of complex systems exhibit similar threshold events –
507 financial markets, ecosystems, and even epileptic seizures and asthma attacks – in which
508 the system seems stable right up until the time when the sudden change occurs [37].

509 Research has provided general ideas on where these thresholds or tipping points might
510 operate with respect to climate – the loss of Arctic sea ice or Antarctic ice shelves, the
511 release of methane into the atmosphere from the melting of Siberian permafrost, or the
512 disruption of the “oceanic conveyor belt” – but this knowledge is rudimentary at best.
513 Scheffer and colleagues [37] report tentative efforts to identify “early warning signs” that
514 precede threshold events, and with respect to climate, they state that “flickering,” “rapid
515 alterations,” or increased weather and climate “variability” seem to have preceded sudden
516 changes observed in the climate record. But at present, predicting these climatic thresh-
517 olds is vague at best. One of the authors explained the idea of thresholds and the
518 uncertainty about them in an interview with *Time* magazine, “Managing the environment
519 is like driving [on] a foggy road at night by a cliff... You know it’s there, but you don’t
520 know where exactly” [38].

521 **Defining and Communicating Uncertainty**

522 Clearly, climate science contains uncertainties that are endemic to the data sources used;
523 to the understanding of processes involved; and to predictions of future trends, impacts,
524 and outcomes. Consequently, it is essential to accompany any study of climate change
525 with careful, explicit, and candid assessments of the levels of certainty or confidence
526 associated with the findings or claims made. Indeed, reports or studies are suspect if they
527 fail to include such information and/or if they make unequivocal statements about “prov-
528 ing” their points. To some extent, the same can be said about commentaries, news reports,
529 or various information sources. While the politicized environment in which climate change
530 is debated might encourage strong and definite affirmations, such statements can prove
531 counterproductive if they are perceived or exposed as exaggerated [14, 39].

532 Numerous approaches exist for defining and communicating uncertainty, and this
533 brief discussion here does not attempt a comprehensive overview. Instead, it focuses on
534 the approach that the IPCC has developed for its assessment reports. The main function of
535 the IPCC is to “assess the state of our understanding and to judge the *confidence* with
536 which we can make projections of climate change, its impacts, and costs and efficacy of
537 options,” but in its first and second assessments (1990 and 1995 respectively), the IPCC
538 gave inadequate attention to “systematizing the process of reaching collective judgments
539 about uncertainties and levels of confidence or standardizing the terms used to convey
540 uncertainties and levels of confidence to the decision-maker audience” ([40], p. 5 empha-
541 sis added). Consequently, the IPCC conducted a comprehensive project to rectify these
542 inadequacies [41, 42], and the result was the following system for defining and commu-
543 nicating uncertainties in the Fourth Assessment Report published in 2007.

544 The first step is to present a general summary of the state of knowledge related to the
545 topic being presented. This summary should include (1) the amount of evidence available
546 in support of the findings and (2) the degree of consensus among experts on the
547 interpretation of the evidence [43]. ▶ *Table 9.1* illustrates how these two factors form
548 interacting continua that produce qualitative categories.

t1.1

Table 9.1

Conceptual framework for assessing the current level of understanding [40, 43]

Increasing level of agreement or consensus ↑	Established but Incomplete High agreement / Limited Evidence	Well Established High agreement / Much evidence
	Speculative Low agreement / Limited evidence	Competing Explanations Low agreement / Much evidence
	→ Increasing amounts of evidence (theory, observations, models)	

549 The IPCC guidance notes for addressing uncertainty ([43], p. 3 emphasis in original)
 550 state that in cases where the level of knowledge is determined to be “*high agreement, much*
 551 *evidence*, or where otherwise appropriate,” additional information about uncertainty
 552 should be provided through specification of a level of confidence scale and a likelihood
 553 scale. The level of confidence scale addresses the degree of certainty that the results are
 554 correct, while the likelihood scale specifies a probability that the occurrence or outcome is
 555 taking place or will take place. The IPCC guidelines state that the level of confidence scale
 556 “can be used to characterize uncertainty that is based on expert judgment as to the
 557 correctness of a model, an analysis or a statement. The last two terms in the scale should
 558 be reserved for areas of major concern that need to be considered from a risk or
 559 opportunity perspective, and the reason for their use should be carefully explained”
 560 ([43], p. 4). Table 9.2 shows the scale. The likelihood scale is used to refer to
 561 “a probabilistic assessment of some well defined outcome having occurred or occurring
 562 in the future” ([43], p. 4).

563 Adaptation and Mitigation

564 The terms “adaptation” and “mitigation” were briefly discussed in the introduction to this
 565 chapter, but the more detailed definition and explanation in Table 9.3 outlines impor-
 566 tant distinctions that will be helpful for the sections of the chapter that follow.

567 Perceptions, Communication, and Language of Climate 568 Change

569 Moser ([44], p. 33) writes that “a number of challenging traits make climate change
 570 a tough issue to engage with,” and she implies that something in the nature of climate

t2.1 **Table 9.2**
 Scales of uncertainty used in the IPCC fourth assessment report, 2007. None of these are statistically significant because no tests are conducted to determine the values. Instead, they are based on expert judgment

Qualitatively calibrated levels of confidence [43]	
Terminology	Degree of confidence in being correct
Very high confidence	At least 9 out of 10 chance in being correct
High confidence	About 8 out of 10 chance in being correct
Medium confidence	About 5 out of 10 chance of being correct
Low confidence	About 2 out of 10 chance of being correct
Very low confidence	Less than 1 out of 10 chance of being correct
Likelihood scale [6]	
Terminology	Likelihood of the occurrence or outcome (%)
Virtually certain	>99
Extremely likely	>95
Very likely	>90
Likely	>66
More likely than not	>50
About as likely as not	33–66
Unlikely	<33
Very unlikely	<10
Extremely unlikely	<5
Exceptionally unlikely	<1

571 change itself makes it more challenging for people to perceive and communicate about
 572 than many other, even related issues (environmental, hazards, health). She lists the
 573 following characteristics of climate change that produce this substantial challenge:

- 574 • Invisible causes: Greenhouse gasses are not visible and have no direct or immediate
 575 health implications. The same is true for other forcing agents such as Earth/Sun
 576 relations.
- 577 • Distant impacts: The lack of immediacy in temporal and geographic distance.
- 578 • Insulation of modern humans from their environment: This diminishes the percep-
 579 tion of any changes in the climate or their significance.
- 580 • Delayed or absent gratification for taking action: Action taken today is not likely to
 581 reduce global average temperature within the lifetime of the person taking the action.
- 582 • The lack of recognition that humans have of their technological power: This produces
 583 disbelief that humans have the capacity to alter the global climate.
- 584 • Complexity and uncertainty: This leads to considerations of climate change taking on
 585 less importance than immediate needs such as family and job responsibilities.

t3.1 **Table 9.3**
 Definitions and explanations of the terms adaptation and mitigation from the IPCC fourth assessment report 2007

t3.2	Adaptation	“Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities: Various types of adaptation can be distinguished including anticipatory, autonomous, and planned adaptation:
t3.3	<i>Anticipatory adaptation</i>	Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
t3.4	<i>Autonomous adaptation</i>	Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.
t3.5	<i>Planned adaptation</i>	Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.” ([3], p 869).
t3.6	Mitigation	“An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.”
t3.7	Mitigative capacity	“This is a country’s ability to reduce anthropogenic greenhouse gas emissions or to enhance natural sinks, where ability refers to skills, competencies, fitness and proficiencies that a country has attained and depends on technology, institutions, wealth, equity, infrastructure and information. Mitigative capacity is rooted in a country’s sustainable development path.” ([3], p 84).
t3.8	Mitigation potential	“In the context of climate change mitigation, the mitigation potential is the amount of mitigation that could be – but is not yet – realised over time.
t3.9		<i>Market potential</i> is the mitigation potential based on private costs and private discount rates, which might be expected to occur under forecast market conditions, including policies and measures currently in place, noting that barriers limit actual uptake. Private costs and discount rates reflect the perspective of private consumers and companies.
t3.10		<i>Economic potential</i> is the mitigation potential that takes into account social costs and benefits and social discount rates, assuming that market efficiency is improved by policies and measures and barriers are removed. Social costs and discount rates reflect the perspective of society. Social discount rates are lower than those used by private investors.
t3.11		Studies of market potential can be used to inform policy makers about mitigation potential with existing policies and barriers, while studies of economic potential show what might be achieved if appropriate new and additional policies were put into place to remove barriers and include social costs and benefits. The economic potential is therefore generally greater than the market potential.
t3.12		<i>Technical potential</i> is the amount by which it is possible to reduce greenhouse gas emissions or improve energy efficiency by implementing a technology or practice that has already been demonstrated. No explicit reference to costs is made but adopting ‘practical constraints’ may take implicit economic considerations into account.” ([3], p 84).

- 586 ● Inadequate signals indicating the need for change: Inertia in the climate system and
587 lack of observable economic or social costs or benefits reduces incentives for action.
- 588 ● Self-interest: Not only are many powerful forces in society interested in maintaining
589 the status quo, but also the majority of people in developed countries defend the
590 comforts of their modern lifestyles, even if unintentionally and unconsciously.

591 Weber [14] adds additional factors that make the perception and communication of
592 climate change difficult. First is the difference between *affect-based* and *analysis-based*
593 processing of environmental information. The general public relies heavily on affect-based
594 processing, that is, relying on personal experience. However, climate change is not easily
595 detected in this manner. Climate, defined above as the aggregate of day-to-day weather
596 conditions that have been averaged over longer periods of time, requires analysis-based
597 processing of statistical information that includes averages, trends, and uncertainty
598 estimates, among others. The majority of people are simply ill-equipped to process this
599 type of information, and they have little patience in attempting to decipher it.
600 Compounding the difficulty is that “People’s fundamental values and worldviews influ-
601 ence which phenomena and risks they attend to and which they ignore or deny” ([14],
602 p. 335). When limited processing capacity and patience wane, people default to reliance
603 on their fundamental values and worldviews, which generate a wide range of responses
604 that are generally politicized and deeply held. Several typologies exist for categorizing
605 these responses, but Ereaut and Segnit ([45], p. 7) have developed a very useful one from
606 empirical studies conducted in the UK that contain the four “repertoires” presented in
607 ▶ [Table 9.4](#).

608 **Future Directions: The State of Climate Change Knowledge** 609 **and Future Predictions**

610 As stated earlier, consideration of human knowledge of climate change and future pre-
611 dictions must differentiate two questions: What is the direction and rate of change, if any,
612 in Earth’s climate? What is the cause, natural or anthropogenic, of any observed climate
613 change? It is almost universally accepted across the scientific community that global
614 average temperature is increasing in accordance with the data presented in the graph in
615 ▶ [Fig. 9.1](#). This is summarized as follows:

- 616 ▶ Since the mid twentieth century, the uncertainties in global and hemispheric mean tem-
617 peratures are small, and the temperature increase greatly exceeds its uncertainty. In earlier
618 periods the uncertainties are larger, but the temperature increase over the twentieth
619 century is still significantly larger than its uncertainty ([22], p. 1).

620 With respect to differentiating natural from anthropogenic causes of this observed
621 warming, although broad consensus of scientific judgment suggests anthropogenic
622 causes, a substantial minority remain less convinced. The IPCC represents the former
623 group that assigns causation to anthropogenic causes. But it has taken almost 20 years for

t4.1 **Table 9.4**
 t4.1 **“Repertoires” employed by people in response to information about climate change [45]**

t4.2	Alarmism	Climate change is constructed as “awesome, terrible, immense, and beyond human control... an inflated or exaggerated rhetoric... urgent tone... quasi-religious register of death and doom... language of acceleration and irreversibility... sensationalism [and that it] undermines its ability to help bring about action.”
t4.3	Settlerdom	“... named after ‘settlers’... people with sustenance-driven needs... optimistic but non-pragmatic... rejects and mocks the alarmist... invoking ‘common sense’ on behalf of the ‘sane majority’... dismisses climate change as a thing so fantastic that it cannot be true... a refusal to engage in the debate... broadly right-wing... immune to scientific argument.”
t4.4	British comic nihilism	“... an evasive rhetorical repertoire... rejection of climate change is whimsical, unserious, blithely irresponsible... a sunny refusal to engage in the debate... comic musings on the positive possibilities of a future with climate change... dealing with adversity and threat by use of humour.”
t4.5	Small actions	“... the eminent ‘pragmatic’ optimist... asking a large number of people to do small things... language of ease, convenience and effortless agency... easily lapses into ‘wallpaper’ – the domestic, the routine, the boring and too easily ignorable... lacking in energy... may not feel compelling... the unspoken but obvious question: how can small actions really make a difference to things happening on this epic scale?”

624 the IPCC to reach this conclusion. Table 9.5 outlines relevant statements from the
 625 various IPCC Assessment Reports spanning the period 1990–2007.

Types of Mitigation Strategies

626
 627 Because the focus of this handbook is climate change mitigation, various mitigation
 628 strategies are detailed elsewhere. Consequently, this section will not attempt thorough
 629 explanation of them, but will briefly list and outline the major types of mitigation
 630 strategies as a foundation for considering the ethical issues associated with them.

631 The most often discussed category of strategies for mitigating climate change is to
 632 reduce the emission of CO₂ that results from the combustion of fossil fuels. Public policy
 633 actions serve as the primary driver for effecting these mitigation strategies. One policy
 634 action is to simply *set limits on the CO₂ emissions* from the various sources (electrical
 635 generation plants, cars, etc.) as the impetus to develop cleaner technologies. A second is
 636 the well-known “*cap and trade*” system in which a government body limits the amount of
 637 CO₂ that can be emitted and then issues (allocates or sells) permits to private firms to emit
 638 specified amounts of CO₂. Firms can then sell or buy permits as needed depending on
 639 their amount of emissions. Cap and trade has been criticized on a number of counts, most
 640 notably: (1) that it increases the cost of fuel and so disproportionately affects the poor

t5.1

■ **Table 9.5**

Statements from the various IPCC assessment reports showing the increasing levels of certainty regarding the causes of the observed increase in global average temperature spanning the period 1990–2007

t5.2

t5.3

t5.4

t5.5

1990. First assessment report ([46], emphasis added)	“The size of this warming is broadly consistent with prediction of climate models, but it is also of the same magnitude as natural climate variability. Thus the observed increase <i>could be largely due</i> to this natural variability; alternatively this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect is not likely for a decade or more.”
1995. Second assessment report ([47], p 22 emphasis added)	“Since the 1990 IPCC Report, considerable progress has been made in attempts to distinguish between natural and anthropogenic influences on climate. The balance of evidence <i>suggests</i> a discernible human influence on global climate.”
2001. Third assessment report ([48], p 31 emphasis added)	“There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities (p. 5). Most of observed warming over last 50 years is <i>likely</i> due to increases in greenhouse gas concentrations due to human activities.”
2007. Fourth assessment report ([49], p. 39 emphasis added)	“Most of the observed increase in global average temperatures since the mid-20th century is <i>very likely</i> due to the observed increase in anthropogenic GHG concentrations. This is an advance since the TAR’s [Third Assessment Report] conclusion that ‘most of the observed warming over the last 50 years is likely to have been due to the increase in GHG concentrations.’”

641 rather than the wealthy; and (2) that in the places where it has been tried, for a variety of
 642 reasons, it has not reduced CO₂ emissions and has resulted in volatile emissions trading
 643 market. A proposed alternative to “cap and trade” is known as the “*fee and dividend*”
 644 *system*, described as follows:

- 645 ▶ ... a fee is collected at the mine or port of entry for each fossil fuel (coal, oil, and gas), i.e., at
 646 its first sale in the country. The fee is uniform, a single number, in dollars per ton of carbon
 647 dioxide in the fuel. The public does not directly pay any fee or tax, but the price of the goods
 648 they buy increases in proportion to how much fossil fuel is used in their production. . .The
 649 carbon fee will rise gradually so that the public will have time to adjust their lifestyle, choice
 650 of vehicle, home insulation, etc., so as to minimize their carbon footprint. . .100 percent of
 651 the money collected from the fossil fuel companies at the mine or well is distributed
 652 uniformly to the public. Thus those who do better than average in reducing their carbon
 653 footprint will receive more of the dividend than they will pay in the added costs of the
 654 products they buy ([18], p. 209).

655 Proponents of the fee and dividend system list some of its additional benefits as (1) it is
 656 revenue neutral in that it does not raise taxes; (2) only a very small government

bureaucracy is needed; (3) it “internalizes” the incentives to reduce the use of fossil energy (e.g., cost savings) across “billions of decisions ranging from commuting behavior to the design of vehicles, aircraft, cities, and so forth” ([18], p. 211); and (4) it raises the cost of fossil energy sources to reflect their cost to society and the environment (pollution, climate change, health impacts, etc.) and to improve the competitiveness of renewables that do not carry these costs. Another climate change mitigation strategy focused on reducing production of CO₂ is *population control*, though it is highly controversial. Proponents argue that increasing human population causes increasing emissions of CO₂, and as a result, stabilization of human population is necessary to stabilize or reduce concentrations of atmospheric CO₂. Opponents respond that people are not pollution, but rather, the blame lies on the system that depends on fossil fuels for economic development. Instead of reducing population, they argue, policy should focus on changing that system. Further controversy has to do with the issues of liberty and family values, which can be said to conflict with policies limiting family size. A final strategy for reducing emissions of CO₂ involves *improving energy efficiency and conservation*. As efficiency increases, less fuel will be used, and as a result, less CO₂ will be emitted. This readily achievable and cost-effective strategy could not only reduce CO₂ emissions substantially but could also significantly reduce the world’s energy demand [50].

In contrast to strategies that reduce the emission of CO₂, the second category of mitigation strategies removes CO₂ from the atmosphere once it has been produced. There are a number of such strategies. *Reforestation* involves the planting of forests, either new forests or the restocking of existing forests that have experienced deforestation, as means to sequester more CO₂ from the atmosphere. The process is explained as follows:

▶ Carbon dioxide is constantly exchanged between the atmosphere, the oceans and terrestrial ecosystems. Vegetation and soils can accumulate carbon, thus reducing the rate of CO₂ build-up in the atmosphere that is responsible for climate change . . . Forest ecosystems contain the majority (approximately 60 per cent) of the carbon stored in terrestrial ecosystems. Thus the world’s forests sequester and conserve more carbon than all other terrestrial ecosystems and account for 90 per cent of the annual carbon flux between the atmosphere and the earth’s land surface ([51], p. 861).

While reforestation efforts have potential to sequester CO₂, the effect is less than envisioned in virtually all such measures. The predominant means of reforestation is the “forest plantation” where a single species of tree is planted. The amount of carbon sequestration has been found to be 28% less in forest plantations than in naturally occurring primary or secondary forests [52]. Consequently, while not diminishing the importance of reforestation, it seems that the most efficient efforts involving forests would be to preserve existing ones. This provides good rationale to pursue a related strategy of *preventing deforestation* which retains the natural, primary and secondary forests.

A second strategy to remove CO₂ from the atmosphere is called *carbon capture and storage* (or sometimes carbon capture and sequestration). Other chapters in this handbook provide considerable detail on this topic, so it will only be briefly defined here. Carbon capture entails trapping the CO₂ at its emission source, then transporting it to

699 a location where it can be stored so that it does not escape into the atmosphere (usually in
700 underground rock formations).

701 A final suite of strategies to mitigate the effects of CO₂ is called *geoengineering*, defined
702 as a “large-scale engineering of the environment in order to combat or counteract
703 the effects of changes in atmospheric chemistry” ([53], p. 433). They take the form of
704 either shielding Earth from incoming solar radiation or facilitating the transport of
705 heat energy from Earth to space, primarily by reducing the concentration of atmospheric
706 CO₂. One of the most talked-about is to inject sulfur dioxide (several million tons per
707 year) into the stratosphere [54], where it would undergo various chemical reactions to
708 produce sulfate particles that would scatter incoming sunlight and thereby cool the planet.
709 It is known that this works because of observations of the effects of volcanoes that produce
710 sulfur dioxide (SO₂), most recently, the Pinatubo volcano that injected over 20 million
711 tons of SO₂ into the stratosphere in 1991, which resulted in a decrease of global average
712 temperature by about 0.5°C (1°F) for about 1 year. Delivery of SO₂ into the stratosphere is
713 proposed using either balloons or with planes burning high sulfur fuel, at an estimated
714 cost of \$25 billion to \$50 billion annually [54]. While studies indicate it would reduce
715 global average temperature, it would not address problems associated with increasing CO₂
716 levels, most notably, acidification of the ocean which causes negative impacts on organ-
717 isms that make calcareous structures, such as shells and corals, along with the ecosystems
718 of which they are a part. A second strategy that promises to reduce global average
719 temperature by reducing atmospheric CO₂ is called *artificial iron fertilization* of the
720 ocean. Such fertilization occurs naturally when dust storms carry iron into the ocean
721 and cause blooms of the photosynthesizing organisms known as phytoplankton. By
722 artificially spreading powdered iron into the ocean, the idea is to promote the phyto-
723 plankton blooms that would absorb CO₂ through the photosynthesis process.
724 A commercial firm named Planktos explored this idea and conducted some small-scale
725 tests. However, they failed to gain adequate investor funding to scale up the project,
726 primarily as a result of questions about various and potentially negative unintended
727 consequences of the project that included adverse effects on marine organisms and
728 ecosystems [55]. This highlights a serious drawback to these and the various other
729 geoengineering strategies, possible unintended consequences that would be global in
730 scale and sometimes unstoppable.

731 **Uncertainties and Moral Obligations Despite Them**

732 The previous section introduced the kinds of uncertainties involved in human under-
733 standing of climate change. The first point to address concerning moral obligations
734 in the face of uncertainty is that it is wrong to overstate the uncertainties involved.
735 This is the case because, in large part, consequences for denying what has been well
736 established include delaying and softening the response to problems that are likely to
737 require significant effort and collaboration to address. Democratically, furthermore,
738 obfuscations of the kinds that the previous section sought to undo, such as in the

739 conflation of the issues of warming global temperatures with the causal forces bringing the
740 warming about, only get in the way of making intelligent progress in addressing either of
741 these concerns.

742 Three issues are worth covering in this section given their bearing on uncertainties and
743 moral obligations despite them. The first concerns the ethics of news reporting about
744 scientific developments regarding uncertainties with respect to climate change. The
745 second regards a fallacy of reason that is committed all too often about climate change.
746 The third one concerns caution and collective obligations in the face of uncertainty.

Ethics and Reporting About Climate Science

747

748 One important development in news reporting has been the recognition that news outlets
749 often exhibit biases. A traditional way of thinking suggested that reporting should only be
750 considered the relaying of facts. This outlook is generally ascribed to modernism and has
751 inspired a reaction that has been called postmodern, a view that holds that no outlook in
752 news reporting can be considered perfectly objective or absolutely without bias. While the
753 postmodern movement has its flaws and excesses, it is not wrong in seeing that the long-
754 held ideal of a “view from nowhere,” a point of view without bias, may be unachievable,
755 imaginary.

756 Building upon postmodern thinking, more pragmatic approaches to knowledge have
757 come to see biases as things to be recognized and controlled. What has come about as
758 a result of this shift is an effort in countless news outlets always to demonstrate balance
759 about issues that get reported. A problem that emerges is that news outlets sometimes
760 make use of commentators, explicitly holding a point of view, but then contrast them with
761 people whose points of view are minimally relevant to the topic being reported.

762 One troubling consequence of this effort to appear more credible, to issue news that is
763 more purposefully and intentionally balanced from a political point of view, is the fact that
764 some people want to deny the findings of science. Examples of this problem include
765 detractors of climate science along with other examples such as those who believe that the
766 age of the Earth should be determined by reading religious texts rather than with the
767 scientific method. In short, when a vocal minority of people speaks up, they can make it
768 appear as though there is balance, a 50-50 way of reporting the facts about scientific
769 developments. When it comes to matters such as climate science, however, this develop-
770 ment is pernicious because it promotes the idea that genuine controversies exist within the
771 sciences when no fundamental disagreement exists among scientists. There is a moral
772 problem at issue here in which some people use the idea of media balance to “spin” a point
773 of view that makes uncertainties appear far greater than they are.

774 The motivations for misinformation or for the propagation of claims unjustified or
775 even contradicted by science are varied. While people certainly have a right to beliefs from
776 religious or other sources, this fact produces tension wherever such beliefs conflict with
777 the findings of science. In many cases, these tensions are dealt with in constructive ways,
778 but in other cases, some persons may think that their interests would be best served if

779 scientific developments were stalled or obfuscated. Efforts of this kind surely produce
780 troubling manipulations of the democratic need for carefully evaluated and verified
781 political as well as scientific information.

Avoiding the Fallacy of Appealing to Ignorance

782

783 Uncertainties about climate change precipitate a common challenge to the idea that action
784 should be taken to address it. There is an important fallacy at play in such arguments,
785 beyond the fact that often obfuscations are made about what uncertainties there are
786 exactly involved in climate change. It is the fallacy of appealing to ignorance.

787 An appeal to ignorance is a fallacy of reason that occurs when one makes a strong
788 conclusion about the state of some subject matter on the grounds that knowledge is
789 lacking about it. Take an example of Jack, who is a serial killer. Mindy and Alex do not
790 know that Jack is a killer, but Mindy has a bad feeling about him, and she says so to Alex.
791 Alex defends Jack by stating, “You don’t actually know that Jack’s a bad guy, so he’s a good
792 guy, really.” Alex holds a kind assumption that people are nice unless proven otherwise,
793 but in this case, it is clearly wrong. Alex moves from the fact that someone lacks knowledge
794 to some other substantive fact that the lack of knowledge clearly cannot substantiate. This
795 fallacy of reason is called an appeal to ignorance.

796 The appeal to ignorance seems to be one of the most common responses to climate
797 change efforts. People tend to imagine or pretend that the science is inconclusive, but in
798 a way that in fact may be insufficient a challenge to the idea that people ought perhaps to
799 take precautions. Beside this precautionary motivation, known as the Precautionary
800 Principle, the fact is that the science is stronger than it has been in many cases portrayed,
801 as shown in the previous sections in this chapter.

The Limits of Challenges About Uncertainty

802

803 The first thing to say here is that the uncertainty people claim is involved in scientists’
804 understanding of climate change is frequently overstated or misstated. In this section, let
805 us imagine that some of the bolder claims about uncertainty with respect to climate
806 change were true. There is still reason, nonetheless, to think that moral obligations could
807 and do exist for people despite such a hypothetically strong uncertainty.

808 The common response in the environmental ethics literature to the challenge
809 of uncertainty is that the potential harm that can come from problems such as
810 climate change can be catastrophic [56]. Thus, even if there is uncertainty about
811 a problem or a very small likelihood of trouble, it is typically wise and a moral obligation
812 to avoid that catastrophic scenario. This is general practice in medical situations.
813 When a set of possible medical courses of action are generally safe and yield little risk
814 of adverse effects, they are almost always what one should do before other options

815 whose effects could be catastrophic. The reason for the moral obligation to choose the less
816 risky option is known as the Precautionary Principle. The Precautionary Principle in the
817 context of climate change resembles what in the history of philosophy has been called
818 Pascal's Wager.

819 Pascal's Wager is about belief in God. He argued that four options exist:

- 820 ● If one does not believe in God and God exists, then a devastating outcome could ensue –
821 eternal damnation for one's disbelief.
- 822 ● If one does not believe in God and there is no God, no problem.
- 823 ● If one believes in God and there is none, then one has lost some time and effort.
- 824 ● If one believes in God and there is a God, then one could receive great rewards.

825 This set of options, Pascal believed, is excellent reason to believe in God. Of course,
826 religious arguments can analyze whether or not such motivations are enough for genuine
827 belief, but the point of relation to the subject here, climate change mitigation, concerns
828 especially the one similar circumstance that could arise for the environment. In other
829 words, what if people do not concern themselves about the environment and in fact allow
830 or increase the chances of catastrophic circumstances as a result? The worry involved there
831 is something akin to that involved in risky medical practices that are not accepted in all but
832 the rarest of cases.

833 The response to the wager for the environmental context is to say that there are costs of
834 mitigation and adaptation to climate change. Of course, if there is no choice but to adapt,
835 then those costs cannot be avoided, though they can be distributed more or less justly.
836 When it comes to efforts to mitigate climate change, however, things like caps on
837 greenhouse gas emissions can have profound effects on the ways in which businesses
838 work. In short, a challenge to the Precautionary Principle emerges related to the cost-
839 benefit analysis of action to address climate change. Neil Manson [56] estimates that the
840 costs of inaction could be seen as enormous, which is why people should not be afraid to
841 enter into discussions about precautions and valuations of climate change. Environmen-
842 talists are often wary of entering into cost-benefit analyses, since it is difficult to value
843 things like the survival of species. However, Manson also argues that environmentalists
844 could devise strategies for valuing the costs of changes to climate. In short, there are
845 a number of important elements that can factor into moral obligation even if there are
846 uncertainties about climate change. There is a whole industry in the insurance business
847 that practices the process of putting monetary value on things that average persons would
848 have an extraordinarily difficult time valuing, since people in general do not think of the
849 world as do those who manage risk for a living. It is important to note here in concluding
850 this section that none of these responses to challenges of uncertainty about climate change
851 should be construed as reason to doubt the increasingly strong evidence that suggests
852 human beings have a significant impact on the environments on a large scale or the even
853 more strongly defended judgment that global temperatures are increasing over the long
854 run, occurrences for which the Precautionary Principle would prescribe that humanity to
855 prepare (see [57] for an explanation of the Precautionary Principle).

Traditions and New Developments in Environmental Ethics

856

857 The study of environmental ethics has grown substantially in the last 30 years. In the
858 background of developments in this study lie cultural beliefs about the world and
859 humankind's place in it. Often, the Earth is conceived as God's gift to mankind, to be
860 used for human purposes. At the same time, things that are gifts from God could also be
861 considered important targets for stewardship. Stewardship refers to the duties one has to
862 objects or property bestowed on oneself in some honored fashion, like a family heirloom
863 or in this case a divine gift. Whether one approaches environmental ethics with a religious
864 motivation or a secular one, a tension arises often between the idea that the Earth is
865 property, a mere tool for human ends, and the opposing belief that human beings have
866 a duty to take the best care they can of shared resources. This tension arises in the study of
867 environmental ethics in the form of arguments that address human interests primarily, the
868 anthropocentric approach, and arguments that give moral weight to things like places,
869 animals, ecosystems, etc. The present section will cover a number of the approaches that
870 environmental ethicists have taken for considering the moral duties human beings have to
871 care for the environments on which they depend. The section will begin with a discussion
872 on the tradition of environmental ethics, focusing on theories about the source of value in
873 ethics. Next, the matter of who is affected in problems of environmental ethics is
874 important to consider. Finally, some recent developments will be discussed, which suggest
875 that a cultural shift is noticeably growing public acceptance for environmental values and
876 precautions.

Sources of Value in Environmental Ethics

877

878 The traditional way of thinking about land and environments has largely been religious. In
879 2010, founder of southern Indiana's Corydon Tea Party Norman Dennison explained
880 a traditional outlook on religiously motivated opposition to understanding about climate
881 change. Dennison explained that human-induced climate change "is a flat out lie."
882 According to a *New York Times* article, Dennison explained that "he had based his view
883 on the preaching of Rush Limbaugh and the teaching of scripture. 'I read my Bible,' Mr.
884 Dennison said. 'He [God] made this earth for us to utilize'" [58]. Here Dennison
885 illustrates contempt for the findings of climate science, to be sure, but he also demon-
886 strates the central background for thinking about environmental concern as uniquely
887 anthropocentric and based on God's purported decision that the Earth is intended to be
888 used up. Rachel Carson has argued that the tradition treats the Earth as an object to be
889 exploited and conquered, without consideration for its well-being [59].

890 Religious outlooks on environmental policy do not exclusively follow Dennison's
891 orientation to deny climate science. Matthew Hay Brown in the *Baltimore Sun*, for
892 instance, asks "Where would Jesus drill?" in his article, "Religious Environmentalists
893 Hope Spill Wins Converts" [60]. What is noticeable, therefore, is that although traditional

894 views may suggest that humankind ought to have great powers over God's gift of the
895 Earth, even in religious discussions, the source of environmental value and what ought
896 to be done is neither settled nor determined for all. In particular, a central challenge
897 to such traditional views concerns the idea that environmental ethics ought to be
898 anthropocentric.

899 One of the most influential thinkers to challenge solely anthropocentric values in
900 environmental ethics was Aldo Leopold. In *A Sand County Almanac*, he called for an
901 expansive view of the source of value in ethics [61]. He named a new kind of ethic the Land
902 Ethic. Although Leopold was a hunter and enjoyed nature very much, he saw in nature
903 a source of value that is independent of his enjoyment of it. In this section, it should
904 become clear that there is common ground to be found between the different views that
905 are presented here. Whether value is inherent in nature or not, ultimately anyone
906 concerned must convince others to share that concern. Therefore, the anthropocentrism
907 or the inherent value theorist like Leopold need to attend significantly to human interests,
908 but to expand people's understandings of what those interests could more intelligently
909 appreciate.

910 The common tendency in debates about ethics and environmental issues is to have
911 human beings pitted against something like an endangered animal. Some people wonder
912 why they must be terribly concerned about rare fish, for example, especially when
913 countless species have gone extinct in the past. Plus, in biology, students are taught that
914 animals survive when they are fit for their environments. Thus, one might argue that any
915 animal that is in danger of becoming extinct is simply showing its unfitness for present
916 conditions, whether those conditions are manmade or not. If they become unfit for the
917 environment by accident or by purposeful human action, what is the moral difference?

918 Environmentalist responses have varied to such challenges, and Leopold's answer is
919 straightforward. He said that inasmuch as you and he have rights and worth and deserve
920 respect in efforts to live, so do other animals and environments. He believed that the
921 problem fundamentally has to do with the fact that people think they simply have no
922 obligation to the things and other forms of life in this world. As such, it follows that the
923 right of things to live and to be can in many circumstances trump human claims on
924 freedom to change the environments in ways that harm the natural habitats of animals,
925 thought Leopold. In this sense, Leopold believed in the importance of human stewardship
926 of land. He saw not only animals and plants as living things, but ecosystems and natural
927 environments as having lives as well. The reason people generally do not think about
928 mountains as alive comes from not seeing the place of mountains in an overall living
929 system and also not looking at them on the right scale. After all, mountains, streams, and
930 grasslands all change and grow, erode, and serve as homes for countless animal and plant
931 species. If people care about their own lives, it is life ultimately that counts, Leopold
932 argued. He saw the history of ethics as a growth in consideration for people and groups,
933 then pets and other cared for things in an expanding circle of consideration. He believed
934 the next step was for humans to broaden consideration even further, to include the
935 environment. The most important element that Leopold brought to the attention of
936 moral thought had to do with this broadening of moral consideration beyond the simply

937 anthropocentric view. Today, the existence of laws about the treatment of animals is one
938 form of outgrowth of theories like Leopold's.

939 Two matters are important to note at this point about global climate change and the
940 ethics involved in efforts to mitigate it and its effects. First, the idea of speaking for the
941 Earth as a whole is one strategy that has been appealed to in ethics. Environmental ethics
942 scholar J. Baird Callicott [62] has on several occasions argued, however, that it is quite
943 certain that the Earth itself will be here whatever human beings do to it. Thus, the strategy
944 of arguing for the Earth's sake, an approach that Callicott claims to be too diffuse to be
945 practical in inspiring people, is also misguided in a greater sense. The people who would
946 argue for human-centered values in ethics are not taking the wrong track. It is life on
947 Earth, including human life, which will be affected substantially by things like climate
948 change. Thus, it is not problematic to focus on the values of environmental efforts that are
949 based on the quality of human life and the cares of human beings.

950 Following Callicott's advice, whether one believes in the independent theory of
951 environmental value or only the anthropocentric theory, it seems most rhetorically
952 powerful to argue according to human interests, but to expand how people think of
953 these. Philosopher Andrew Light has taken this approach, for example [63]. One might
954 differ from Leopold in how to defend things like unique fish in a river that could be
955 destroyed due to some construction change or industrial practice and might instead
956 consider the possible effects of such changes for human beings. One way to think of
957 human interest with regard to generally unfamiliar animals or environments has been
958 studied under the category of "ecosystem services" [64]. Among the effects that have been
959 considered in arguing for the defense of ecosystems are the kinds of benefits that come
960 from biological diversity. The first among these is the fact that animals serve as food for
961 other animals. As such, then, when one species is wiped out, it almost invariably has
962 a rippling effect on other species, who either have to change their diets substantially,
963 sometimes failing and thus dying out also, or bringing a substantial shift in effect on
964 other animals that then become prey, potentially wiping them out. The number of animals
965 and species affected can be enormous, then, from one simple change in biodiversity in
966 a particular environment. When one realizes the breadth of possible effects from climate
967 change, the results could be truly catastrophic [4]. The idea of "ecosystem services" points
968 out the fact that humans get things like clean drinking water from a whole ecosystem.
969 When people affect a significant element of an ecosystem, a great chain of events can mean
970 danger for human beings as well as the animals and environments initially altered.

971 The skeptic could ask, however, what it matters if an ecosystem changes substantially,
972 beyond the occasional cases in which things like drinking water are affected. What
973 practical consequences are there for human beings in other cases? The first answer here
974 would be that human beings enjoy their environments. Change to those environments
975 could easily affect human beings negatively, therefore. Examples include changes for
976 simple appreciation of beautiful environments that become less beautiful – the element
977 of aesthetics in ethics. When one's landscape is beautiful and valuable as such, one's
978 property values decrease significantly if the environments become less beautiful and
979 desirable, which is a financial aspect of an aesthetic change. Another aesthetic change

980 similarly can occur for hunters, who are no longer able to enjoy either their hunting
981 environments or the animals that they hunt because of effects on populations due to
982 environmental changes. As mentioned above, Leopold was a hunter too, who enjoyed
983 environments as he respected their inherent value at the same time.

984 A second consequence could be agricultural. When an animal is eliminated that would
985 otherwise keep insects in check, crops can be devastated all of a sudden because the insects
986 are more able to multiply in huge numbers. Famines can result from such changes, if crops
987 become devastated. The costs of shifts in agriculture are more immediately obvious for
988 human interests. They can also be direr for human beings than aesthetic changes. In
989 relation to issues of climate change, whatever the cause of changes in climates, farmers
990 have begun to report the need to change the kinds of crops that they farm because of
991 environmental changes. According to Mendelsohn,

992 ► The largest known economic impact of climate change is upon agriculture because of the
993 size and sensitivity of the sector. Warming causes the greatest harm to agriculture in
994 developing countries primarily because many farms in the low latitudes already endure
995 climates that are too hot. . . Even though adaptation will blunt some of the worst predicted
996 outcomes, warming is expected to cause large damages to agriculture in developing
997 countries over the next century ([65], p. 5).

998 Agriculture, economies, and food supplies are each threatened by changes in climate,
999 therefore. So, when confronting problems in ethics for climate change, cost and benefit
1000 analyses of action surely bear weighty elements for consideration. At the same time, the
1001 people who are affected by these costs are important to consider. The point here at first,
1002 however, has simply been to show that one does not abandon consideration of environ-
1003 mental problems when one takes the impacts on human beings of things like climate
1004 change as essential sources of value for decision making. After all, those who care deeply
1005 about the value of a certain species alone need to make their cases in ethical debates with
1006 human beings, who bring their interests to the table. The strength for such persons,
1007 however, in the process is the profound impact on people that changes in environments
1008 can have.

1009 Persons Who Experience Benefits and Costs

1010 The subject of who is affected by changes in climate is important to consider. There is an
1011 intensely complex set of conflicting interests involved in considerations of who is affected
1012 by climate change and by efforts to mitigate it. The tradition in ethics has nearly always
1013 been to consider first and foremost the values and effects on persons who are presently
1014 living when debating the costs and benefits of action or of constraints on freedom. In the
1015 case of climate change, there certainly are people who are affected in the present through
1016 changes in things like aesthetics, hunting, and agriculture, as outlined in the previous
1017 section. For example, rivers that are drying up and that had attracted animals in some

1018 countries now no longer bring them, which affects agriculture and a vast number of
1019 organisms, in turn affecting food supply and economies for human beings [65].

1020 At the same time, some of the greatest potential worries about climate change are
1021 expected to come in the next few generations, not in the present. Thus, when it comes to
1022 ethics, an important question arises concerning the nature of present human beings'
1023 responsibilities to future generations. After all, the people to whom some say living
1024 human beings have obligations are not even here today. They have not yet been born.
1025 How can people alive today have moral obligations to nonexistent people? The Stern
1026 Review [66] has generated fairly profound impact on this subject, and the basic arguments
1027 have been summarized by the editors of *Scientific American*:

- 1028 ► * Future generations will suffer most of the harmful effects of global climate change. Yet if
1029 the world economy grows, they will be richer than we are.
- 1030 * The present generation must decide, with the help of expert advice from economists,
1031 whether to aggressively reduce the chances of future harm or to let our richer descendants
1032 largely fend for themselves.
- 1033 * Economists cannot avoid making ethical choices in formulating their advices.
- 1034 * Even the small chance of utter catastrophe from global warming raises special problems
1035 for ethical discussion ([67], p. 97).

1036 There are a number of practices already observable that offer examples to follow
1037 regarding these questions of responsibilities to generations that are not present. First,
1038 when persons die, in most societies, people honor obligations to persons who have passed
1039 away. Part of the reason for this has to do with legal codes and part of it has to do with
1040 resolving conflict among the living about those who die. But there are ways in which
1041 people honor those who have died in various ways, such as with memorials.

1042 What is more interesting for the present issue of debate has to do with future
1043 generations. With regard to them, politicians in recent years, such as Senator John
1044 McCain, have argued for clear obligations to children and grandchildren in the United
1045 States. McCain argues that accruing debt today is wrong because of the negative effect it
1046 will have on future generations, who will be "saddled" with debt [68]. In these instances,
1047 politicians like McCain raise problems about the national debt and the deficits that cause
1048 it to grow. What deficits do is to increase the country's future financial obligations to pay
1049 back loans incurred for the purpose of present spending. Those who defend such spending
1050 argue that there are long-term effects of such spending, such as in rebuilding an economy
1051 that can pay back the debts and avoid greater recessions or another depression. At the
1052 same time, then, both sides of the debate about rising deficits are making claims about
1053 moral obligations both to present *and future* citizens. The claim some detractors make
1054 about government spending is that it is irresponsible, it is wrong, to create negative future
1055 financial circumstances for future generations – children, their children, and their chil-
1056 dren after that. The argument goes that people have obligations to their children's
1057 grandchildren. Such ideas are not farfetched, and they can be seen clearly to apply to
1058 matters of environmental ethics.

1059 Those who would reject obligations to future generations make quite a controversial
1060 claim. The more common line would be by analogy to the idea of proximity. In some
1061 ethical circumstances, it seems quite clear, for instance, that people have obligations to
1062 help someone if they can when that person is close and is in great pain. If people can help
1063 and choose not to do so, they allow greater suffering to continue than would occur if they
1064 were to intervene. Thus, in the view of some moral philosophers, people are partly
1065 responsible for the outcome that ensues from inaction. Even inaction has effects, in
1066 other words. The key point here is that one may have an obligation to help someone
1067 drowning 15 ft away, but the person who is drowning a mile away is someone either who
1068 cannot be helped or who is not sufficiently proximal. A better example is starvation, since
1069 it is not quite as immediate a problem. If someone nearby is starving and so is someone far
1070 away, people have a tendency to think that either the person close to them is the one for
1071 whom they have the greater obligation, or it is the person with the greater pain. When all
1072 things are equal regarding the extent of the suffering, people perhaps naturally feel
1073 a greater obligation to those who are closest to them. Translate this trend that is here
1074 described spatially to the temporal level and the same pattern seems to hold. If people are
1075 starving today, human beings seem to have a far greater moral obligation to them than to
1076 address the starvation of possible people who may or may not come to be born tomorrow
1077 or in several generations. This at least is the set of options for considering obligations to
1078 people present and in the future. The common motivation for taking present and close
1079 persons to be more important is understandable, therefore, all things equal, compared
1080 with people who are not present or close. The trouble is, however, that the future which is
1081 put on hold in moral consideration could be deeply affected by choices that provide only
1082 small benefits or pose only small costs today. In fiscal terms, consider the US Congress
1083 throwing an incredible national party at enormous expense to future generations. It may
1084 be fun, but the benefits would be short-lived and appear incredibly thoughtless to future
1085 generations who then have to suffer the burdens of an inconsiderate earlier society. When
1086 it comes to ethics and climate change, it is hard to think that people have no obligation to
1087 future generations. There are also long-term predictions that appear quite worrisome
1088 given the apparent increase in the rates of temperature rise and other factors relevant to
1089 climate change. Thus, policymakers must think about the environmental crisis that future
1090 generations might have to face, much as they already consider the problem of passing on
1091 debt to future generations of children and grandchildren.

1092 Beyond the problems of obligations for present and future persons is the fact that the
1093 costs and benefits of constraints on freedom and of positive action regarding climate
1094 change mitigation are disconnected. In other words, the persons who are affected by costs
1095 are rarely the same people who reap benefits. The following are three important examples
1096 of this idea.

1097 The first example concerns persons currently affected by climate change. Consider the
1098 farmers who presently have to change their crops or who have lost their crops and the
1099 potential to raise them. Whether climate change can be attributed clearly to the produc-
1100 tion of greenhouse gases or not, the persons who are benefiting from greenhouse gas
1101 consumption the most, especially the recipients of wealth that come as a result, or at least

1102 the persons most likely to pay the costs of action about climate change, typically the
1103 wealthier nations, are either going to lose some of the benefits they get or incur some of the
1104 costs of the response to climate change mitigation when they themselves are to a far less
1105 devastating extent affected by the change in climate. In this sense, then, climate change is
1106 something unlikely to be addressed in profound ways by individuals acting only in their
1107 own self-interest, at least until sufficient problems occur to bring about a serious threat for
1108 the wealthier nations and persons. In this sense, then, the disconnection in present time is
1109 a real problem for bringing about one kind of response to climate change mitigation. It
1110 makes it far more likely that any real effort to address climate change will take place
1111 primarily at the state (national) level or through channels for which there is private benefit
1112 for making changes, which might include for instance the development of energy-efficient
1113 technologies that get sold for profit.

1114 Another similar disconnect occurs at the level of present and future people. For, while
1115 future consequences can only be addressed by present people at any given time, benefits in
1116 equations of cost and benefit can seem less weighty because future people are not present.
1117 As such, then, the people who will make the sacrifice for future generations are present and
1118 feel less the impulse to help those whom they cannot see. This entails the idea of
1119 discounting the future. The problem occurs in many spheres. When roads are unsafe
1120 but are costly to change, it often takes catastrophe in terms of loss of life for people to feel
1121 sufficiently motivated to bring about change. The same problem occurs for issues of fiscal
1122 discipline. Also, the arguments against present action in favor, for instance, of allowing
1123 present businesses to continue unhampered in their practices that promote climate
1124 change see importance in the effects of changes to economic success as ripples. In other
1125 words, greater constraint on economic growth now can have negative effects on future
1126 generations also. The matter of who is affected by climate change and efforts to mitigate it
1127 is quite complicated, therefore, and is most likely to occur at the larger, state level or at the
1128 level of vast agreements for changes that are established with cooperation between
1129 government and industry.

1130 A further disconnect is important to notice in considering who will be affected by
1131 constraints on the production of greenhouse gases or other efforts to mitigate climate
1132 change. Poor nations argue that limitations on their industries are limitations on their
1133 development. In other words, when burning fuels like coal is the cheaper energy route that
1134 makes places like China and India grow, they argue that to push them not to use such fuels
1135 is unfair in terms of market competition. They argue that the United States and other such
1136 wealthy nations that industrialized first would perpetuate poverty in poor nations for the
1137 sake of environmental concerns, when poor countries' development needs are great.
1138 Therefore, the people affected by efforts to change industries, practices, and efforts that
1139 mitigate climate change not only concern poor farmers and wealthy nations, but also
1140 those nations seeking economic growth out of poverty. They wish for the freedom to
1141 develop in ways that will bring masses of people out of poverty, raising the standard of
1142 living for human beings in poor places. The result of making allowances for such cases,
1143 however, is that those nations who accept responsibility to act for the sake of mitigating
1144 climate change may argue, with debatable merit, that double standards are hypocritical.

1145 These kinds of problems and arguments demonstrate how difficult it is and will be to
1146 create significant coalitions in efforts to mitigate climate change. The web of conflicting
1147 interests involved renders the problem of laying out a simple ethic of environmental
1148 action enormously difficult. The motivation for clarifying these issues, however, is pow-
1149 erful nonetheless, since the potential harm to humanity of inaction could be
1150 catastrophic. Incredibly complex circumstances have been resolved before, but only
1151 with great effort and time. The effort and time spent to date in climate change have yet
1152 to resolve these issues.

1153 New Developments

1154 With still so much to be developed about the future of climate change, adaptation options,
1155 and potential methods of mitigation, the ethical responsibilities involved may take shape
1156 in a variety of ways. An important shift has occurred since the start of the environmental
1157 movement. That shift is cultural. A movement has taken hold to consider future steps for
1158 addressing environmental problems. Early on in the environmental movement, there was
1159 far less study of environmental science than is available today. Cultural elements like the
1160 development of recycling systems have become common place in countless population
1161 centers worldwide. Plus, what started as an apparently politically polarized concern for the
1162 environment has grown to be recognized in many spheres. Just one example of this is in
1163 sanitation. It is clear to people that the faster landfills fill up, for instance, the sooner new
1164 costs will come for more land, farther carrying of trash at greater fuel expenses, etc. Also, in
1165 communities with well run recycling efforts, municipalities can see financial benefit from
1166 the materials recycled that would otherwise just fill up landfills. These elements I call cultural
1167 because they are not measures that address climate change directly. Rather, they are elements
1168 of a culture of consideration for what it means to be a part of an ecosystem today.

1169 At one level, something like a cultural shift is necessary, since no one solution is likely
1170 to resolve the problems of climate change. Andrew Light's environmental pragmatism
1171 suggests an effort to move beyond traditional philosophical debates about the nature of
1172 environmental value. He argued that "the important thing to impress upon environmen-
1173 tal philosophers [is] the need to take up the largely empirical question of what morally
1174 motivates human to change their attitudes, behaviors, and policy preferences toward
1175 those more supportive of long-term environmental sustainability" ([63], p. 446). What is
1176 most likely is that a variety of efforts combined will be necessary to bring about both the
1177 will for change and the consequent support for public policy that addresses environmental
1178 concern adequately. Those efforts should include both adaptation and some potential
1179 measures of mitigation, and these will inescapably have to be joined with developments in
1180 new technologies whose benefits should bring about a decrease in harmful emissions,
1181 a decrease in demand for finite energy resources, and an increase in sustainable practices.
1182 These joint goals do not yet have a singular solution for achieving them all, but together
1183 they embody the various important elements that will enable cultural shifts in energy use
1184 and thus emissions to take hold in wealthier nations and abroad. But the problems of

1185 climate change may require drastic action in some regions, and with any drastic action
1186 costs arise, both in carrying out the action and in dealing with its new effects. The most
1187 effective outcomes will likely occur with the help of interdisciplinary teams working in
1188 concert to bring about maximally beneficial environmental results, such as are starting to
1189 arise with projects like architectural planning for new buildings. Even if changes come,
1190 yielding a culture of concern for the environment, however, some new developments in
1191 ethics and in climate change considerations will grow increasingly important and complex
1192 and will continue to challenge cultural beliefs and practices. These including the following:

- 1193 ● The need for new technologies, such as trapping of GHG's, and energy efficiencies
- 1194 ● The possible need for population controls and the conflicts that will likely arise
1195 regarding fairness and freedom in relation to such controls
- 1196 ● Policies and plans for the future migrations of people who have no other choice
- 1197 ● Challenges of dividing up responsibilities when changes require costs
- 1198 ● The offset of cost involved in choosing practices that are sustainable over ones that are
1199 simpler and cheaper, but at greater environmental cost

1200 A final consideration is worth noting. There are regions in which people do not yet
1201 live. In those places, there are natural resources that could be gathered. Among these
1202 circumstances is the Arctic National Wildlife Refuge (ANWR) in the United States, which
1203 has been at the center of controversy about drilling for oil in new locations. People argue
1204 that America ought to exploit this location since no one uses it. A few considerations
1205 already mentioned combine in rendering such cases more complex. For instance, it could
1206 be claimed that such areas will not have future benefit for people because people do not
1207 travel there. As climate changes, however, it is altogether possible that uninhabitable
1208 places become inhabitable. In that process, places like refuges near the poles will become
1209 more frequented as a result of the thawing of cold regions, but it is uncertain whether or
1210 not future generations will make use of such refuges. In this instance, then the problem of
1211 uncertainty for the future returns, while not directing specific action – since people must
1212 not commit the fallacy of appealing to ignorance – it is important nevertheless to raise the
1213 question about whether it is true that the ANWR will not be used in the future. Also, it
1214 appears that climate change, while potentially devastating in some regions, may bring
1215 benefit to colder regions to some degree. Finally, the matter of responsibilities to future
1216 generations arises, when coupled with these first two considerations, showing concern for
1217 children and grandchildren, who may one day frequent places like the Arctic National
1218 Wildlife Refuge. Nevertheless, the people of today need to be concerned about sources of
1219 energy, as well as their economic well-being. For, without the necessary financial and
1220 energy resources, expensive efforts to mitigate climate change will be impossible.

1221 Conclusion

1222 Changes in climate are of the immensely complex sort that will require consideration
1223 about a vast array of responsibilities and inputs. This fact has slowed the development of

1224 a culture of environmental concern, but today that culture is building and appears to
1225 recognize more than ever before the need for concerted efforts to get ready for the greater
1226 changes and costs that climate change will bring about. For the present volume on climate
1227 change mitigation, the focus has been on terminology, options for mitigation, as well as
1228 the various ways of thinking and the considerations that should be taken into account for
1229 ethical approaches to human conduct about climate change. At the same time, in the cost
1230 and benefit analyses to be used in evaluation of the various methods that are and will
1231 become available for responding to new problems, it is important to factor in options for
1232 adaptation to new circumstances, remaining as open as possible to intelligent deliberation
1233 about the ideal resolution of the problems of climate change. People must also take into
1234 account the fact that measures to mitigate climate change always come with costs of their
1235 own, both direct and indirect. The fact that there are costs to the work of addressing
1236 climate change, however, ought not to be seen as implying that the world would lose
1237 equally from action as from inaction. Climate science, mitigation strategies, and pro-
1238 jections of adaptation options, all are becoming better understood as further inquiry
1239 develops into these areas. Skepticism is often a healthy force in inspiring further study and
1240 justification for public action. Past skepticism has inspired more and more study over
1241 time, which appears to be converging on the conclusion that the need for action must be
1242 taken seriously and proposals weighed. This chapter has been aimed at exposing readers to
1243 a number of issues related to a broad understanding of climate change, mitigation, and the
1244 moral norms that ought to be taken into account as international efforts are shaped to
1245 address the future of the global climate.

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