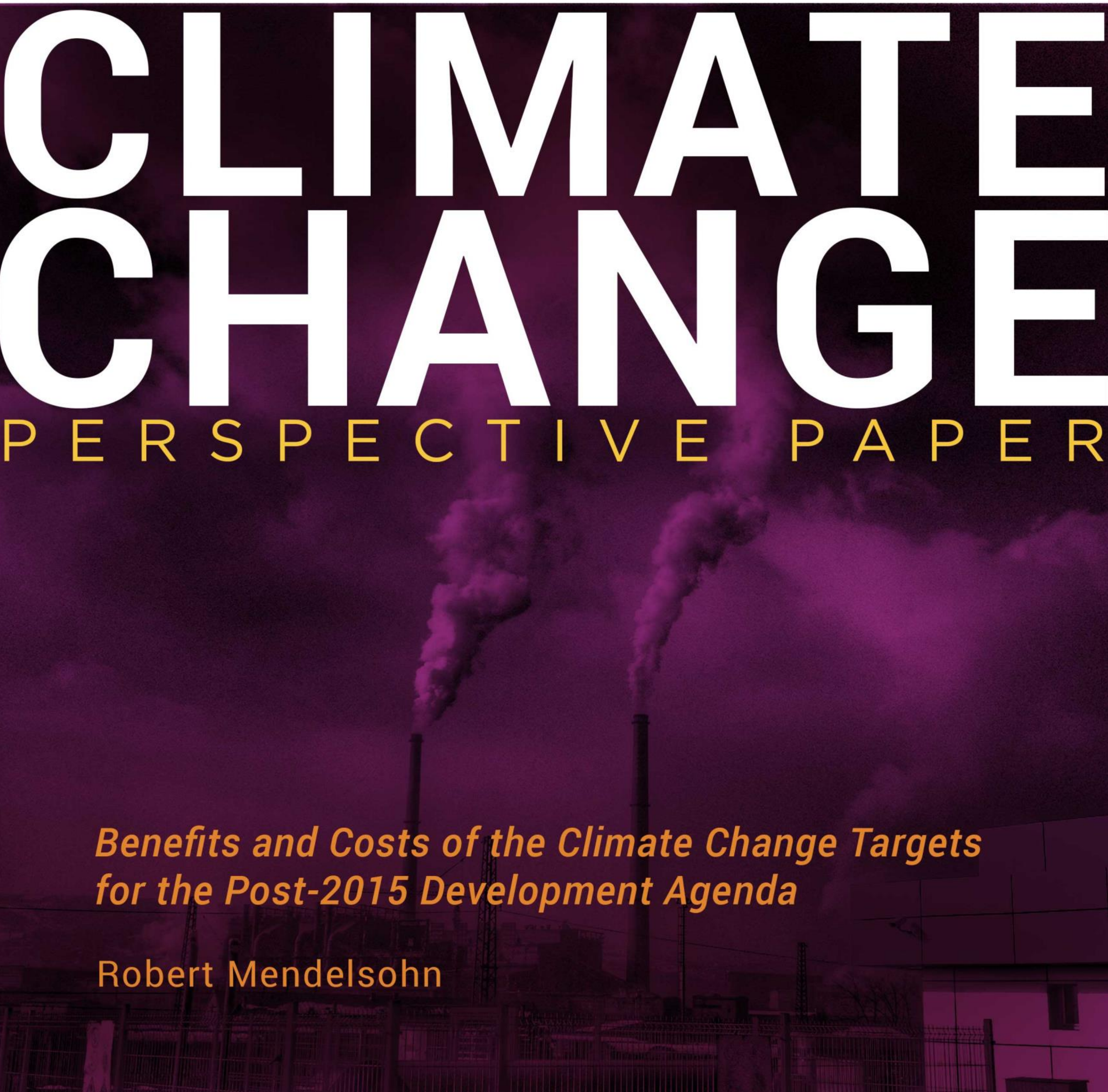
COPENHAGEN CONSENSUS CENTER

CLIMATE CHANGE

PERSPECTIVE PAPER



Benefits and Costs of the Climate Change Targets for the Post-2015 Development Agenda

Robert Mendelsohn

Benefits and Costs of the Climate Change Targets for the Post-2015 Development Agenda

Post-2015 Consensus

Robert Mendelsohn
Yale University

Working Paper as of 15 October, 2014

Abstract

The optimal solution to the greenhouse gas problem minimizes the sum of the climate damage and the cost of mitigation over the long run. The current United Nations initiative on climate change is not even close to achieving this goal. First, the United Nations, in choosing to limit warming to 2^0C, has selected an unnecessarily demanding and costly mitigation target (2^0C) with low returns. Second, the United Nations initiative has failed to encourage universal participation making the program ineffective. Third, the program places little weight on choosing cost effective tools and technologies to reduce climate damage. Although addressing climate change is worthwhile, the United Nations initiatives have little payoff, encouraging countries to delay even beginning to curb emissions.

Recommendation: start with a modest climate goal that can actually be achieved. Hold warming to 4°C and begin immediately to meet this target. This target has relatively low costs so that it will not bankrupt countries nor prevent economic growth. A modest climate target will prevent the worst climate damage and yet will not foreclose a prosperous future. The climate program does not have to consume all the resources of the international community thus allowing multinational organizations such as the United Nations to pursue many of the Millennium goals simultaneously. Aggressively pursue a cost effective mitigation strategy that will achieve the desired target with minimal waste. Encourage individuals, firms, and nations to pursue adaptation in order to keep the sum of climate damage and adaptation cost as low as possible.

Introduction

Economists have long clarified the goal of climate policy. For the entire world, the objective is to minimize the sum of the present value of the climate damage and the cost of mitigation (William Nordhaus 1991). There are several insights that follow from this simple principle. First, the mitigation cost should be balanced against the climate damage. Specifically, the marginal cost of mitigation should be equated to the present value of the marginal climate damage. Second, as the marginal damage rises over time with higher concentrations of greenhouse gases, the marginal cost should also rise. There is an optimal dynamic path to mitigation. Third, the marginal cost of mitigation at any moment in time should be equated across all emitters. Every country that emits greenhouse gases should participate. Every emitter in every country should mitigate until they equate their marginal costs. These simple principles will minimize the mitigation cost of achieving any particular mitigation target. They will also minimize the sum of the climate damage and mitigation cost associated with greenhouse gases.

Identifying the desired global objective of a climate program is easy enough. But there are some serious political difficulties associated with mitigation. The objective for each country is not the same as what is best for the globe. Each country, and for that matter, each emitter, is tempted to minimize the sum of their own mitigation costs and their own climate damage. But countries are responsible for only a small fraction of their own climate damage. This "global common problem" encourages each country to do very little mitigation. Making matters even worse, most greenhouse gas emissions come from middle to high latitude countries. That is therefore where most of the mitigation must occur. Yet most climate damage falls heavily on low latitude countries which emit comparatively little. Without international cooperation, individual countries have very little incentive to address greenhouse gases.

Even without this political problem, translating theory into practice is daunting. What exactly are the costs of mitigation and what is the climate damage from greenhouse gas emissions? These empirical issues are complex because they involve the entire world. Greenhouse gas emissions from anywhere in the world can affect the climate across the entire world. Greenhouse gases accumulate over time implying that the solution involves decades if not centuries of mitigation. Political institutions are poorly suited to commit to long term policies as most politicians (and voters) have very short time frames. The lowest cost mitigation strategies involve long term commitments.

The greenhouse problem is further complicated by the long delay between the action of emitting a ton of emissions and the climate consequence. The climate damage is spread across centuries. The long delay between mitigation and damage raises questions about discounting. How important are near term costs versus far future impacts? Politicians and voters tend to give very little weight to far future impacts. Even the market which makes many long term decisions is not used to time frames that stretch into centuries. Is there any desire to solve problems that will not materialize for a hundred years?

Mitigation Costs

One guide to greenhouse gas mitigation is to understand where the manmade emissions are coming from. The primary source of greenhouse gas emissions is the burning of fossil fuels to create energy. There are additional emissions associated with deforestation, cement, agriculture, and waste streams but these are relatively minor compared to energy. Energy consumption is the highest in the wealthiest countries. But a considerable amount of energy is also generated by countries that are emerging, transitioning from less developed towards developed economies. The developed and emerging countries are each responsible for about 45% of global emissions. The only countries that have little to do with global emissions are the least developed countries. Because developed and emerging countries generate most of the greenhouse gas emissions, they must also do most of the mitigation.

Many proponents seek to push single technologies as the sole response in a mitigation strategy. Although some future technology may be a "silver bullet" that alone is sufficient to manage greenhouse gases, at present there are limits to every known technology. The cost effective plan is a portfolio of technologies.

One component of the portfolio is to simply reduce energy use. Unfortunately, energy is a valuable input to production and consumption. One can forego energy consumption and one can substitute capital for energy, but it is expensive to reduce energy substantially. Energy conservation is definitely a component of effective mitigation but it cannot be expected to cover more than a fraction of the reductions in emissions.

Analysts have also argued that we can just switch from fossil fuels high in carbon to fossil fuels low in carbon. More specifically, we can shift from coal and synthetic fuels towards natural gas. Fracking has made this suggestion more economical as it has vastly increased the overall supply of natural gas and caused natural gas prices to fall. Clearly moving from coal to natural gas is part of the solution. But even with fracking, the supply of natural gas is limited, and even natural gas emits greenhouse gases so that this again is only a partial solution.

Another choice is to move towards zero emission energy sources. One can move towards solar voltaic and wind power. Wind power has become more efficient in the last few decades making it nearly competitive with fossil fuels. Solar remains more expensive but it too has seen large cost reductions with technical change. As with all energy sources, these renewables have a rising supply curve. The first units may be relatively cost effective but costs rise rapidly with scale. There are only so many good locations for wind and solar facilities. The more a grid depends on these sources, the more it needs backup sources or batteries to even out power production over time. The locations for these sources are not always adjacent to where energy is needed. Again these limitations suggest there is a role for renewable energy but it is limited.

Crops can also be grown for energy. The most cost effective crop is sugar cane but corn has also been used for energy. Countries with substantial cropland naturally are looking at these lands as potential energy sources. Unfortunately, it takes a great deal of land to produce substantial amount of energy. As cropland is diverted to energy, food becomes ever more expensive raising the cost of this alternative. The higher prices of food encourage land currently in forest to move into agriculture. Deforestation increases reducing carbon in forests. When these factors are all included, there is only a limited role for agriculture to provide energy.

Other zero emission sources must also be utilized. Hydropower remains the largest renewable energy source. As the value of hydropower continues to rise, it will become ever more important to dam the remaining free flowing rivers of the world. Efforts to mitigate some of the damage of dams can protect natural resources such as fisheries. But there inevitably will be the loss of some natural environments to greenhouse gas mitigation. The more important greenhouse gas mitigation becomes, the more such sacrifices must be made.

Nuclear power must also be part of the mitigation strategy. Although clearly nuclear power has its own problems with waste management and potential accidents, it is a proven energy technology that produces zero greenhouse gas emissions. Nuclear power is not effective enough to solve the greenhouse gas problem all by itself but it is important that it be part of the solution.

Carbon capture and storage (CCS) is a very large part of most climate solutions. This technology captures the carbon dioxide in the smokestack associated with burning a fuel, compresses it into a liquid, and then thrusts it in the earth. One possible use of this technology is to allow the widespread use of available fossil fuels. The limitation is that it would be costly, though it is not clear how expensive it will actually be. The other potential use is to combine CCS with biofuels (BECCS) so that carbon dioxide could effectively be pumped out of the atmosphere. This is the most promising technology to date to generate negative emissions that actually reduce atmospheric concentrations of greenhouse gases. In addition to cost, the other potential limitation of CCS is finding a permanent storage site. Although scientists postulate several earth formations that might be suitable, there are no long term experiments in place that actually test whether compressed carbon dioxide would stay in any of these formations for very long. It is critical that such tests begin so that the feasibility of this technology can be assessed.

One final potential mitigation strategy is to rely on forests to store carbon. In principle, the world's forests can hold (store) more carbon than they currently do primarily in above ground biomass (although also in soils and slash). Forest owners can be encouraged to take actions such as fully stocking forests, prolonging rotations, and increasing growth that would lead to more storage. A BECCS program that relies on woody biomass would also encourage a substantial increase in forest carbon as more forests would be grown to supply the biomass to burn in the CCS power plant. Using forests for sequestration is cost effective in every mitigation strategy. Using woody biomass in a BECCS program is expensive and is only justified if carbon prices are high enough.

Economics provides a number of additional insights on mitigation costs. First, universal participation substantially lowers the cost. If half the emitters do not participate, the cost of the mitigation program doubles. This is why the essay puts such weight on getting universal participation. Second, the optimal solution is involves a portfolio of available technologies. If cost effective technologies are dropped from consideration, the overall cost of the program rises quickly. Third, the stricter the cumulative target, the more urgent that mitigation begins immediately. Every delay in striking a target effectively causes the cumulative target to rise. The long delays to reach an effective international agreement to date have made the 2°C target a very expensive solution.

But the most important insight of the mitigation research is that the cost of mitigation rises rapidly the more stringent the target. Examining the results implicit in all the Integrated Assessment Models of climate change, small reductions in cumulative emissions tend not to cost very much. Every technology can be used sparingly. One can adopt technologies slowly and take advantage of technical change. One does not have to abandon vast amounts of existing capital but can instead allow existing capital to slowly live out its economic lifetime.

The present value of the global cost of shooting for a 5°C target is likely to be in the range of $10 trillion. The incremental cost of going from 5°C to 4°C is another $10 trillion. However, the incremental cost of going from 4°C to 3°C is another $20 trillion. Finally, the incremental cost of going from 3°C to 2°C is about $60 trillion. Each incremental step costs more and more. Each incremental step requires more action sooner. In fact, the 2°C target requires the system to overshoot (warm beyond this point) and invest in negative emissions to eventually reach the target.

The costs cited assume the program is cost effective. All emerging and developed countries must participate immediately and fully. All cost effective technologies must be utilized. In short, the more aggressive policies require immediate effective international agreements and institutions. Those agreements and institutions do not exist at the moment. If the programs are not cost effective, they will cost a lot more. The world is not yet prepared for a large scale cost effective mitigation program. It will take many years to put into place the necessary institutions and programs. The more aggressive targets do not allow for such delays.

Damage

What sectors of the economy are likely to be damaged by climate change has been known for decades. As stated in the Second Assessment Report of the IPCC, the vulnerable market sectors include agriculture, forestry, energy, water, and coasts. The vulnerable nonmarket sectors include ecosystems (endangered species and migration), health, and aesthetics. The cause of these damages is a combination of changes in temperature, precipitation, and sea level. The primary concern is the shift in the mean of these climate distributions but there is also concern about changes in the variance and the extremes of climate.

Before getting into the details of each sector there is an important insight of impact research that has not been totally understood in policy circles. A large fraction of the potential damage from climate change can be avoided by adaptation. Although mitigation is very difficult to secure, adaptation is hard to prevent. Individuals, firms, local communities and nations all have an incentive to adapt. It is the exact opposite problem with mitigation where everyone has an incentive not to mitigate. Adaptation will happen. Much of it without any policy intervention needed. What do policy makers have to do for adaptation? Some adaptations involve many beneficiaries. Adaptations that protect public goods such as health, ecosystems, and infrastructure all require government involvement. In most cases, the institutions and governments already exist. Local governments, regional water authorities, and park systems are already in place. They can perform the adaptations required. It is only in circumstances where governance is already poor that additional institution building is needed. The bottom line is that one cannot address climate impacts without simultaneously understanding adaptation.

Perhaps the most feared outcome of global warming is that global food production will fall. Small changes in either precipitation or temperature are not likely to have large effects on global production. The beneficial increase in carbon dioxide is likely to mitigate the initial harmful effect of warmer temperature for the planet as a whole. However, even marginal warming is likely to be harmful to low latitude farms but beneficial to high latitude farms and will therefore have distributional impacts even if the aggregate net impact is modest. As warming increases, the harm to low latitude farms intensifies whereas the benefit to high latitude farms shrinks. If farmers adapt to climate in the future as they have to climate in the past, warming of 1-2°C will only have modest effects on global output. Temperatures warm beyond 2°C above current climate, however, will begin to shrink global agricultural production. Because the demand for food is inelastic, damage increases rapidly beyond this point.

Another fearsome effect of greenhouse gases concerns coastal impacts. A large fraction of the world's population, capital, and production is located near coasts. Coasts are threatened by a combination of sea level rise and increasing storm intensity. Both factors threaten to inundate valuable property and cause loss of life. Sea level rise is caused by a combination of expanding the sea by warming it and melting ice sheets. The sea level rise over the next century could potentially inundate valuable swaths of existing cities. However, this land could relatively easily be protected with walls and other hard structures. The annual damage of sea level rise with adaptation is therefore likely to be in the tens of billions of dollars. On top of rising seas, there is evidence that at least tropical cyclones in critical ocean basins may intensify with warming. Tropical cyclones already cause about $26 billion of damage each year across the planet and this number is likely to double with continued population growth and continued economic development along the coasts. If tropical cyclones intensify because of climate change, they could cause another $50 billion of damage annually.

Impacts to forestry over the next 100 years are expected to be largely beneficial. Forests are expected to prosper in a warmer, wetter, CO_2 enriched world. Forests are expected to both expand and become more productive. This will slightly increase the supply of timber to the world yielding a small annual benefit in the neighborhood of a hundred million dollars per year.

Many climate models predict that runoff will decline in the future. This will restrict the supply of fresh water in many basins. About 85% of water withdrawals are to irrigate farms. If this supply is limited, farmers will have to be more water efficient or shift to rainfed farming. However, the most valuable use of water is for urban and industrial uses. The magnitude of the damage in the water sector depends heavily on the extent that the supply to urban and industrial users is curtailed. If water managers substantially reduce supply to urban and industrial users, there will be large losses from runoff reductions in the tens of billions of dollars. However, if water managers restrict water losses to users who place the lowest value on water (primarily farmers), losses can be held to billions of dollars.

The energy sector will also be affected by climate change. There are relatively minor effects to power plants concerning cooling their facilities and to power lines that might lose some of their ability to conduct power. But the largest impact concerns the energy needed for space cooling and heating. Warming will make cooling more expensive and heating less expensive. In a temperature climate, the total energy required for both remains almost the same. However, the cost of cooling is higher than the cost of heating, so this is expected to be damaging. In warmer climates, the cooling damage dominates and in colder climates, the heating benefit dominates. Most of the world's population lives in relatively warm climates. Historically, their space cooling demand for energy was low because they were poor. However, as they have become richer, their cooling demand has increased rapidly. Future economic growth in the low latitudes is projected to be high. The future damage from increased cooling demand is therefore likely to be one of the biggest damages of global warming in the tens of billions of dollars.

The nonmarket impact of ecosystem change is also projected to be a serious impact. Ecologists are concerned about shifting ecosystems, lowered productivity, and lost species. The consequence of these changes to the economy has already been captured in the forest and agriculture sectors. But ecosystem changes are likely to also affect quality of life. People clearly enjoy the ecosystems that they live in and they value biodiversity. It is well understood that climate change will cause biomes to shift over space moving towards the poles and higher altitudes. This will cause some biomes to become larger and others to shrink. The sign of the impact depends upon whether more valuable biomes increase or decrease in size. The sign of the impact also depends upon whether the productivity of the biome falls or increases and whether the above ground biomass in an ecosystem falls or rises. The projected ecosystem impact of climate changes over the next century is that more valuable biomes such as forests will expand and that less valuable biomes such as deserts and tundra will shrink. Ecosystem productivity (net primary productivity) and above ground biomass are both expected to increase. The expanding habitat that these shifts imply should have a positive impact on animal populations. The overall impact will be positive. Of course, not every animal and plant will necessarily be better off in a future climate. Animals and plants associated with shrinking biomes will be worse off. In balance, though the changes in ecosystems wrought by climate change appear to be positive.

One of the most valuable services that ecosystems provide is outdoor recreation. People enjoy skiing, hiking, hunting, fishing, and wildlife viewing in ecosystems. Although the skiing will clearly be hurt by warming, the remaining activities are expected to benefit. Warming extends the period that people can enjoy the remaining outdoor activities. Empirical research reveals that outdoor activities are much more prevalent in warmer climates. Warming will likely increase outdoor recreation.

Another large class of potential damage lies in human health. The extent of many diseases depends upon pathways that are climate sensitive. Vector borne diseases require climates that support carriers such as mosquitoes and flies. Some waterborne diseases are intensified with floods and extensive rainfall. High temperatures can reduce worker efficiency, increase minor ailments such as asthma, and can even cause premature death. The formation of ozone increases at higher temperatures. All of these pathways lead to potential health effects that could threaten millions of lives. However, there is every reason to believe that health effects will actually be modest. Public health responses to most of the vector borne diseases can be very effective at low cost. Economic development will likely drop background levels of most of these diseases before warming has any effect. Further, the cost of preventing additional cases of vector borne diseases is relatively low so that most of these threats will simply entail a slight increase in public health expenditures. Heat stress is also relatively easy to counteract with increased cooling and relatively simple public health measures such as providing the elderly with cool refuges. The increased cost of cooling is a damage that is already captured in energy sector damage. The primary health consequence of warming is likely an increase in public health expenditures on the order of hundreds of millions per year.

Another nonmarket impact of climate is a direct aesthetic appreciation of weather. People travel to enjoy the climates of foreign lands and pay more to live in “better” climates. Most tourist travel is from cold to hot places implying that warming at first will be beneficial. Locations with higher property values tend to be temperate implying a more hill shaped relationship between preferences and temperature. The immediate effects of warming on home expenditures are likely beneficial in cool places and damaging in warm places. As warming increases, the damage is likely to increase and the benefit to shrink.

The final concern with climate change is that it might trigger a catastrophe, a substantial change across the entire planet. The melting of the large ice sheets on Greenland and Antarctica are good examples of catastrophe. A 25 meter increase in sea level will inundate vast swaths of coastal land and force substantial migration towards the interior of every continent. Melting vast glaciers cannot be done instantaneously. The sea level rise is likely to take many centuries. The catastrophe would unfold slowly, effectively doubling the speed of projected annual sea level rise. The cumulative damage would be large but it would be spread across many years. The annual damage of this catastrophe would be about twice the annual cost of traditional sea level rise.

When one sums all of these effects together, there are some valuable insights. Small amounts of warming are not likely to cause large damages. It is very difficult to determine the sign of the impacts from the 1°C warming the planet has already experienced. The impacts are not easily separated from the noise. But impacts will become clearer as the planet continues to warm. As warming increases to +2°C (1°C above current levels), net impacts should become harmful. Once warming reaches +3°C (2°C above current levels), net global impacts are likely to rise to a $100 billion per year. If greenhouse gas emissions are not curtailed, these climate damages should be evident by the end of this century. Warming beyond this point will become ever more harmful. Damage could increase substantially with +4°C reaching annual levels as high as 1 trillion dollars. Without mitigation, such warming is likely in the early 22nd century.

Conclusion

If one accepts that the optimal strategy is to minimize the sum of the mitigation cost and damage associated with climate change, there are some clear policy conclusions. The solution requires an international agreement across all large emitting countries. The solution has to be forward looking because the benefits of controlling climate all lie far into the future. Mitigation is very expensive so every effort has to be made to make the program efficient. A wasteful program is doomed. The mitigation program must begin immediately. Delay causes the background levels of greenhouse gases to continue to rise unchecked causing the world to start with ever higher background levels of warming. All of these propositions are well understood and are not controversial.

The more controversial issue that must be addressed is the balance between costs and benefits. There are two problems. First the magnitude of damages is smaller than what most people understand. Second, the damages are long delayed whereas the mitigation costs must be spent right away. The current United Nations program has chosen +2°C as the target of mitigation. The present value of the mitigation cost of this program approaches $100 trillion. This essay argues this target is too stringent. The worst of warming will occur with temperatures exceeding 4°C. The present value of a program holding warming to 4°C would cost only $20 trillion. The resulting stream of annual damage would be in the neighborhood of a $1 trillion and it would begin in about 100 years. If this damage is judged to be too high, the world could opt for a more expensive mitigation program and hold temperatures at +3°C. The additional cost to this tougher target is another $20 trillion but this lower target would hold damages to about $100 billion a year by the end of this century. The question is whether the additional $20 trillion is worth the reduced damage. The much more stringent target of 2°C will cost another $60 trillion. This would lower damage to trivial levels. Should the world spend $60 trillion to prevent a stream of $100 billion damages that begins in 70-80 years?

One of the reasons that the benefits listed above are so much smaller than what advocates of stringent policies suggest is that adaptation to climate change is both possible and inevitable. Mankind lives in climates that range over 20°C. The swing in temperature every day is over 5°C. There is every reason to believe that people, firms, and governments can and will adapt to relatively small climate changes. If they adapt, the damage of climate change shrinks dramatically. The adaptation does not have to be perfect to substantially reduce climate damage.

Regardless of the size of the desired mitigation program, one thing that is clear is that a perfectly efficient program is unlikely to be equitable. The countries doing the most emissions are not the countries that will be harmed by warming. The victims of climate change are largely low latitude rural residents whereas the beneficiaries of energy consumption (the cause of climate change) are largely mid to high latitude urban dwellers. If one believes that polluters should pay for their emissions, the victims deserve compensation. The fact that the polluters have above average incomes and the victims have below average incomes adds further weight to the call for compensation. Mitigation is not a substitute for compensation because there will be remaining damage even with mitigation and because the cost of mitigation is spread across the planet in the form of higher prices and lower incomes. The ideal compensation is enhanced development for low latitude countries that will diversify their economies away from climate sensitive sectors such as agriculture and provide sustainable income to help soften the blow of future damage.

A final component of climate policy that should be mentioned is insurance. The problem of climate change unfolds far into the future and it is likely that we do not understand all of the consequences of our current actions. The world needs an insurance program in case we are making grievous errors. If we are abating too much, we can clearly simply stop. But if we are abating too little, there may be few mitigation options in the future to correct the mistake. Policy makers need an option to halt climate change abruptly if it is surprisingly bad. That option entails geoengineering. Research on the impacts of geoengineering should be undertaken immediately to determine how best to implement such a program, how effective it would be, and what are the unintended consequences. The actual implementation of geoengineering can wait until an emergency arises, but having a possible response to runaway warming is only prudent.

This paper was written by Robert Mendelsohn, Edwin Weyerhaeuser Davis Professor of Forest Policy and of Economics at Yale University. The project brings together 62 teams of economists with NGOs, international agencies and businesses to identify the targets with the greatest benefit-to-cost ratio for the UN's post-2015 development goals.

For more information visit post2015consensus.com

COPENHAGEN CONSENSUS CENTER

Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on how much social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 100+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.