PURDUE UNIVERSITY | Extension

Illinois - Indiana Sea Grant
agriculture.purdue.edu
IISG21-RCE-ERP-037 - ID-524-W

CLIMATE CHANGE:

Climate Change and Sustainable Development

Update authors:

Melissa Widhalm, Operations Manager, Purdue Climate Change Research Center

Kara Salazar, Assistant Program Leader and Extension Specialist, Purdue Extension, Illinois-Indiana Sea Grant

Leslie Dorworth, Aquatic Ecologist, Illinois-Indiana Sea Grant

Previous authors:

Leslie Dorworth, Aquatic Ecologist, Illinois-Indiana Sea Grant

Robert McCormick, Planning with POWER Project Leader, Illinois-Indiana Sea Grant

Land Use Development

Development patterns standardized after World War II have spread U.S. communities out from urban centers, taking over lands that were previously in agricultural production or open space. As a result, distances between homes, stores, and jobs have increased, creating an automobile-dependent lifestyle. Furthermore, street networks now have large blocks and cul-de-sacs that foster additional driving and congestion while inhibiting walking. The segregation of land uses, which separates homes from schools, work, and other activities, have been reinforced through a combination of governmental policies, investment, and private-sector practices. These policies and development practices have led to populations distributed by income, housing type, family status, race, and age (Rothstein, 2017). Furthermore, the built environment patterns and exclusion of uses have led to many suburban development designs that tend to isolate and exclude people from participating in their community and with one another.

Greenhouse Gases and Climate Change

Our energy-intensive development practices are contributing to increasing levels of greenhouse gases in the atmosphere, which are leading to shifting climate patterns. Gases that exhibit these "greenhouse" properties come from both natural and human sources and include compounds such as water vapor, carbon dioxide, methane, and nitrous oxide. These gases have the unique ability to let light from the sun (solar radiation) pass through the atmosphere freely but they absorb the heat radiating off the Earth (infrared radiation), preventing heat from escaping into outer space. This "greenhouse effect" is a natural process that keeps our world warm enough to sustain life, but small changes in the amount of these important greenhouse gases create big changes in Earth's temperature. Human activities that produce greenhouse gases lead to an "enhanced greenhouse effect" that now warms the Earth beyond what would otherwise be naturally occurring.

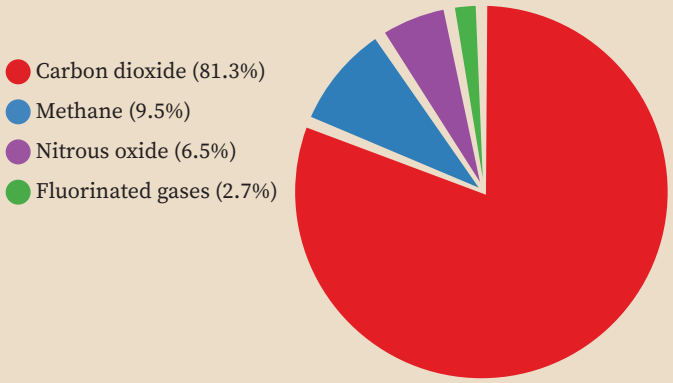
Naturally occurring sources include volcanoes, ocean evaporation, and soil decomposition. However, the most abundant sources of gases today are from human activities.

Scientists discovered the basic relationship between increasing greenhouse gases due to human activities and warming global temperatures back in the mid-1800s. Today, scientists are able to use sophisticated computer models to quantify the impact of greenhouses gases on Earth's entire climate system, and provide scenarios of future temperatures based on likely human actions. The scientific community agrees that human activities increase greenhouse gas concentrations and that these gases contribute to climate change (USGCRP, 2017). What they have concluded is that as concentrations of greenhouse gases increase in the atmosphere, temperatures will warm and rainfall patterns will shift. Storm intensities will be altered and sea levels will rise, leading to devastating losses of life and massive economic disruptions worldwide. Observations over the last century have shown these shifts, commonly referred to as "climate change," are already underway. The U.S. National Climate Assessment reported high confidence that more than half of the observed global average temperature rise since 1951 is a result of human influence on the climate (USGCRP, 2017). International climate change goals set forth in the 2016 Paris Agreement recommend limiting overall global temperature increases to well below 2°C (3.6°F) compared to pre-industrial levels. A more preferred goal of limiting warming to 1.5°C (2.7°F) would require countries to cut emissions by 45% by 2030 (IPCC, 2018).

In the United States, greenhouse gas emissions from human activities come primarily from the combustion of fossil fuels associated with electricity generation, industrial applications, and transportation. Energy use is largely driven by economic growth, with short-term fluctuations in its growth rate created by weather patterns affecting heating and cooling needs, as well as changes in fuel used in electricity generation. Energy-related carbon dioxide emissions, resulting from the combustion of petroleum, coal, and natural gas, represented 81 percent of total U.S. human-caused greenhouse gas emissions in 2018 (EPA, 2021a). The values in the figure represent U.S. Anthropogenic (human-caused) Greenhouse Gas Emissions by Gas, 2018 (Million Metric Tons of Carbon Dioxide Equivalent).

U.S. Greenhouse Gas Emissions by Gas, 2018

Emissions in million metric tons of carbon dioxide equivalents



Source: U.S. EPA's Inventory of U.S. Greenhouse Gas Emmissions and Sinks: 1990-2018. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Methane comes from landfills, coal mines, oil and natural gas operations, and agriculture, representing approximately 10 percent of total emissions. Nitrous oxide (7 percent of total emissions) is emitted through the use of nitrogen fertilizers, burning fossil fuels, and certain industrial and waste-management processes. Several human-made gases, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6) that are released as byproducts of industrial processes and through leakage, represent 3 percent of total emissions. The U. S. Environmental Protection Agency has declared that carbon dioxide and other greenhouse gases are a significant threat to human health and are listed as pollutants under the Clean Air Act.

Implications for Development

Transportation is the largest consumer of petroleum and other liquid fuels, particularly motor gasoline and distillate fuel oil. Currently, fuel economy standards have stopped requiring additional efficiency increases by 2025 for light-duty vehicles and by 2027 for heavy-duty vehicles, but travel continues to rise, and as a result, consumption of petroleum and other liquid fuels continues to rise resulting in the generation of greenhouse gases and concurrent reduction in local air quality (U.S. Energy Information Administration, 2021).

There are several strategies that communities can implement to reduce vehicle miles traveled (VMTs), which have direct implications for air quality and physical activity. The Federal Highway Administration collects data for the indicators through state traffic data counts. Potential strategies to reduce VMTs include ride sharing programs, high occupancy vehicle lanes, and expanding public transportation. (https://www.fhwa.dot.gov/policyinformation/)

Development strategies such as compact, mixed-use development patterns and redeveloping infill and brownfield areas in existing neighborhoods can promote biking, walking and opportunities for expanding bicycle and pedestrian infrastructure. Communities can utilize VMT data to evaluate policies and strategies that reduce traffic while improving air quality and public health. Additional strategies and resources can be found on the U.S. Environmental Protection Agency's State and Local Transportation Resources website: epa.gov/state-and-local-transportation.

Additionally, the emerging concept of remote work communities or "Zoom Towns" have the potential to reduce VMTs. However, communities will need to proactively plan for the influx of new, remote working residents, particularly those in rural and scenic areas. For example, addressing affordable housing and the implementation of broadband development will need to be a key focus in communities where it is lacking (Stoker et al., 2021). Researchers from the University of Utah created the Gateway and Natural Amenity Region Initiative, including an online toolkit and strategies for communities to consider as they are transforming to a remote work culture: https://www.usu.edu/gnar/index. Additionally, Indiana's Office of Community and Rural Affairs' (OCRA) Rural Broadband efforts include grant programs, technical support, and research, among other resources for Indiana's rural communities: https://www.in.gov/ocra/additional-resources/rural-broadband/.

Sustainable Development Strategies and Climate

To further support a variety of climate change mitigation and adaptation efforts, communities can use sustainable development approaches to guide planning, design, and development. Sustainable development is an overarching concept that incorporates a long-term approach to decision making, a holistic outlook integrating various disciplines, and a new appreciation of the importance of place and proactive involvement in societies and ecosystems. From an international scale, the United Nations member states developed and adopted the 2030 Agenda for Sustainable Development as a shared blueprint for peace and prosperity for people and planet, which includes 17 Sustainable Development Goals (United Nations Department of Economic and Social Affairs Sustainable Development, 2021). Each member, including the United States, tracks sustainable development goals on a national level. For example, Goal 11, Make cities and human settlements inclusive, safe, resilient, and sustainable, includes a series of indicators, statistics, and data sources related to sustainable development to benchmark and track progress (U.S. National Statistics for the U.N. Sustainable Development Goals, 2021).

Sustainable development strategies provide opportunities to redesign communities to reduce climate change impacts while also positively impacting human health and well-being (US EPA, 2017). For example, compact, mixed-use development patterns can reduce time spent commuting, protect farmland and open space with affiliated zoning, and can improve water quality, air quality, and public health through the reduction of airborne pollutants when vehicle miles traveled are reduced (US EPA, 2017; Susman, 2017). This type of development pattern looks like neighborhoods designed with shops, offices, schools, churches, parks, and other community amenities near homes, so that community members and visitors have options of walking, bicycling, or taking public transportation. Pedestrian-friendly environments strongly correlate with decreases in negative health indicators such as obesity, diabetes, hypertension, and asthma while auto-dependent development patterns contribute to a more sedentary life style (CDC, 2018; Department of Health and Human Services, 2020). Furthermore, land-use policies are responsible for either contributing to or eliminating food deserts. A food dessert is a geographic area that lacks access to local fresh foods, local community-assisted agriculture, and community gardens, which all make positive contributions to public health (APA, 2015).

Tools to bring about sustainable development at a local level consist of measures that establish standards for building or planning such as ecological footprint analysis, carbon calculators, environmental assessment and reporting, institutional and policy mechanisms, education and consensus building, organizing, and coalition building. Each of these approaches emphasize interconnections between issues such as land use, transportation, housing, economic development, environmental protection, and social equity. As an example, the Smart Growth Network, a partnership of government, business, and civic organizations, developed a set of 10 basic principles, collectively described as smart growth strategies (US EPA, 2021b). The US EPA guidebook, Smart Growth Fixes for Climate Adaptation and Resilience, provides an overview of strategies for community implementation, categorizes them by type of policy or regulatory change, and indicates other impacts to which a strategy might be relevant (US EPA, 2017). The following 10 smart growth strategies outline example considerations for protecting water quality and natural resources while also promoting public health and community quality of life (US EPA, 2021b).

1) **Allow Mixed Land Use:** *The integration of mixed land uses into communities is a critical component of achieving better places to live and thereby improving the quality of life for the residents.*
   - Allow mixed-use options with zoning ordinances.
   - Zone areas by building type, not by building use only.
   - Convert abandoned malls to mixed use.
   - Provide financial incentives for mixed use.
2) **Use Compact Building Design:** *Provide opportunities for communities to incorporate more compact building design as an alternative to the conventional, land-consumptive development practices.*
   - Emphasize communication of Design not Density.
   - Balance street type and building scale.
   - Ensure access to parks and open space.
   - Ensure privacy with yard design.
   - Reduce impervious surfaces to minimize stormwater runoff.
3) **Increase Housing Choice:** *Provide housing choices for all income levels.*
   - Identify and market vacant buildings.
   - Revise codes to widen choice by builders.
   - Enact an inclusionary zoning ordinance.
   - Support community land trusts for homebuyers.
4) **Create Walkable Communities:** *Create places where people live, work, learn, and play and that make these communities desirable from any point of view.*
   - Connect neighborhoods with pathways.
   - Locate amenities near homes.
   - Improve sidewalk infrastructure and accessibility.
   - Make walking safe (crosswalks, speed bumps, traffic islands).
   - Connect shopping areas with pathways, sidewalks, and trails.
5) **Foster Distinctive, Attractive Communities with a Strong Sense of Place:** *Develop a vision and set the appropriate standards to meet the vision for development and construction within the community. The standards therefore correspond to the community's values of architectural beauty and distinctiveness, as well as provide greater choice in available housing and transportation.*
   - Protect and preserve what is unique to the area.
   - Plant trees; protect older trees during construction; have open spaces; preserve scenic vistas.
   - Allow sidewalk vending, dining, kiosks, etc.
   - Create opportunities for community interaction.
   - Use visual cues to define neighborhoods.
   - Establish funds for historic preservation.
   - Develop "wayfinding" systems in town centers.
   - Highlight cultural assets through public art and event nights.
   - Provide funding to create places of distinction.
6) **Protect Farms, Unique Natural Features, Critical Environmental Areas, and Open Spaces:** *Preserve critical environmental areas to improve a community's quality of life; guide new growth into existing communities.*
   - Inventory special places and make plans to protect them.
   - Establish zoning to encourage clustering.
   - Protect farmland and open lands through purchase of development rights (PDR) or a transfer of development rights (TDR)
   - Work with land trusts.
   - Connect greenways.
   - Adopt urban agriculture policies.
7) **Direct New Development Toward Existing Communities and Infrastructure:** *By directing new development back towards the communities and using already existing infrastructure and resources, you ultimately conserve open space and natural resources on the urban fringe.*
   - Facilitate programs that encourage home renovation and rehabilitation in existing neighborhoods.
   - Locate new public buildings in the town center, not on the fringe.
   - Strengthen infill and brownfield programs.
   - Upgrade existing infrastructure first.
8) **Offer A Variety of Transportation Choices:** *The key is making available to the residents more choices in housing, shopping, communities, and transportation.*
   - Provide auto, bicycle, pedestrian, and transit options.
   - Link modes of transportation.
   - Build higher density around transit stops.

9) **Make Development Processes Predictable, Fair, Efficient, and Cost Effective:** *Make sure that the private sector is engaged in the process.*
   - Conduct an audit to update local codes.
   - Assist developers who try new sustainable development projects.
   - Use point-based project evaluation to encourage sustainable development.

10) **Involve Community Stakeholders:** *Make sure that the community is intimately involved in the process of sustainable development practices, since the residents of the community know how they want their community to grow and their vision of self is reflected in their community.*
   - Seek professional assistance in community outreach and engagement and integrate it throughout a planning process.
   - Ensure diversity, equity, and inclusion is a central focus for community engagement.
   - Use visioning.
   - Ensure community ideas are included in the planning process.
   - Work with the media.
   - Consider new ideas.

Additional strategies to leverage smart growth with climate adaptation include proactive planning for renewable energy and extreme weather events. In addition to planning for large-scale renewable development, proactively amending codes and adopting ordinances to allow solar and wind energy on a variety of properties provides for more options and guidance for what is allowed to alleviate contentious disagreements (Susman, 2017). Planning and managing for increased extreme weather events such as storms and heat to protect vulnerable populations can be accomplished through updating flood maps and mapping out hot zones. Implementation strategies, including green infrastructure, rainwater harvesting, cooling centers, and cooler hardscapes need associated ordinance updates to alleviate barriers to actively address extreme events (US EPA, 2017; Susman, 2017). The successful implementation of sustainable development policies and strategies ultimately depends on collaborative and intentional community engagement with land-use decision-makers and local leadership to update comprehensive plans and local ordinances while also funding associated implementation strategies.

References

American Planning Association (APA). (2015). Health in the development review process. https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Guidance-for-Health-Development-Review-Process.pdf.

Centers for Disease Control and Prevention (CDC). (2018). *Prevalence of overweight, obesity, and severe obesity among adults aged 20 and over: United States, 1960–1962 through 2015–2016.* https://www.cdc.gov/nchs/data/hestat/obesity_adult_15_16/obesity_adult_15_16.htm.

Department of Health and Human Services. (2020). *Healthy people 2020*. https://www.healthypeople.gov/2020/about/foundation-health-measures/Disparities.

IPCC, 2018: Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)].

Rothstein, R. (2017). *The color of law: A forgotten history of how our government segregated America*. Liveright Publishing Corporation.

Stoker, P., Rumore, D., Romaniello, L., & Levine, Z. (2021). Planning and Development Challenges in Western Gateway Communities. *Journal of the American Planning Association*, 87:1, 21-33.

Susman, M.M. (2017). Using smart growth to adapt to climate change. *Zoning Practice*, *American Planning Association,* 2, 8.

U.S. Department of Transportation. (2015). https://www.transportation.gov/mission/health/vmt-capita.

References *(continued)*

U.S. Energy Information Administration. (2021). *Annual energy outlook 2021*. https://www.eia.gov/outlooks/aeo/.

U. S. Energy Information Administration. (2020). *Energy and the environment explained: Greenhouse gases*. https://www.eia.gov/environment/.

U.S. Environmental Protection Agency. (2021a). *Inventory of U.S. greenhouse gas emissions and sinks.* https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

U.S. Environmental Protection Agency. (2021b). *Smart growth*. https://www.epa.gov/smartgrowth.

U.S. Environmental Protection Agency. (2017). *Smart growth fixes for climate adaptation and resilience*. https://www.epa.gov/sites/production/files/2017-01/documents/smart_growth_fixes_climate_adaptation_resilience.pdf.

U.S. Global Change Research Program (USGCRP). (2017) *Climate Science Special Report: Fourth National Climate Assessment, Volume I* [Wuebbles, D. J., Fahey, D. W., Hibbard, K. A., Dokken, D. J., Stewart, B. C. and Maycock, T. K. (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp.

United Nations Department of Economic and Social Affairs Sustainable Development. (2021). *The 17 Goals*. https://sdgs.un.org/goals.

U.S. National Statistics for the U.N. *Sustainable Development Goals*. (2021). https://sdg.data.gov.

Also in this series

https://www.extension.purdue.edu/extmedia/ID/ID-519-W.pdf

https://mdc.itap.purdue.edu/item.asp?Item_Number=ID-520-W

Reviewed by: Zachary Kennedy and Amanda Mosiman

Sea Grant ILLINOIS-INDIANA

PURDUE UNIVERSITY
Purdue Climate Change Research Center