CH.4 Opportunities for Multiple Sectors

CLIMATE CHANGE POSES SIGNIFICANT CHALLENGES for more than our nation's ecosystems. Its impacts also will be felt in cities and towns, and in sectors such as agriculture, energy, transportation and other infrastructure, housing, and water resources. The anticipated impacts to those sectors have been well documented and the threat of climate change has already prompted important adaptation efforts.

It is important to consider not only the impacts of other sectors on species and their ecosystems, but to look for opportunities for coordinated adaptation strategies that provide co-benefits.

Chicago is installing "green" roofs that put vegetation on top of buildings and "cool" pavement that reflects light to tamp down anticipated heat waves (Hayhoe and Wuebbles 2010). Keene, New Hampshire, has upgraded storm-water systems and other infrastructure after being hit by devastating floods (City of Keene, New Hampshire 2007). Native Americans are moving entire villages in Alaska and making trout habitat more resilient in Michigan (Buehler 2011). Overall, at least 17 states have or are developing climate adaptation plans. At the federal level, adaptation efforts are being coordinated by the ICCATF and are described in the October 2011 *Progress Report of the Interagency Climate Change Adaptation Task Force* (CEQ 2011).

All of these affected interests will respond to climate change impacts in their own way, and the decisions made in these sectors will ultimately impact our nation's fish, wildlife, and plants. At times, adaptation efforts taken by these sectors can conflict with the needs of ecosystems (maladaptation). For example, south-western cities diversifying their water supplies may take vital water away from wildlife and farmers. But far more often, climate change adaptation can benefit multiple sectors. Restoring wetlands to provide more resilient habitats also can improve water quality and slow floodwaters helping downstream cities. Protecting coastal ecosystems also helps protect communities and industries from rising sea level along the coast. Moreover, research on the economics of climate adaptation shows that it can be far cheaper to invest in becoming more resilient now than to pay for damages caused by climate change later (ECA 2009).

In working to reduce climate change impacts on fish, wildlife, and plants, it is important to consider not only the impacts of other sectors on these species and their ecosystems, but to look for opportunities for coordinated adaptation strategies that provide co-benefits. These sectors can take actions that also reduce non-climate stressors on ecosystems. For instance, precisely matching fertilizer amounts to the differing needs of each section of a field can cut overall fertilizer use and nutrient runoff, thus reducing the algal blooms that stress aquatic ecosystems and increase their vulnerability to climate change (e.g., increasing water temperatures).

It is outside the scope of this *Strategy* to describe in detail the climate change impacts on various sectors or their adaptation needs. Instead, this chapter briefly describes relevant climate impacts and recommends actions for managers in these sectors to promote co-benefits and ensure that the needs of fish, wildlife, and plants are considered in their climate adaptation efforts.

There are seven overarching climate adaptation strategies, common to all sectors, that can benefit fish, wildlife, and plant adaptation:

1 | Improve the consideration of impacts to fish, wildlife, and plants in the development of sector-specific climate adaptation strategies.

2 | Enhance coordination between sectors and natural resource managers, land-use planners, and decision makers regarding climate change adaptation.

3 | Use integrated planning to engage all levels of government (local, state, federal, and tribal) and multiple stakeholders in multi-sector planning.

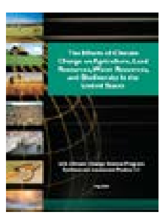
4 | Make best available science on the impact of climate change on fish, wildlife, and plants accessible and useable for planning and decision-making across all sectors.

5 | Explicitly consider natural resource adaptation in sector-specific climate adaptation planning.

6 | Improve, develop, and deploy decision support tools, technologies, and best management practices that incorporate climate change information to reduce impacts on fish, wildlife, and plants.

7 | Assess the need for, and the utility of, expanding compensatory mitigation requirements for projects that reduce ecosystem resilience.

ADDITIONAL RESOURCES ON IMPACTS TO OTHER SECTORS



National Action Plan: Priorities for Managing Water Resources in a Changing Climate (ICCATF 2011)

The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States (CCSP 2008d)

Effects of Climate Change on Energy Production and Use in the United States (CCSP 2007)

Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I (CCSP 2008b)

Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region (CCSP 2009a)

The Washington Climate Change Impacts Assessment (Climate Impacts Group 2009)

Wisconsin Initiative on Climate Change Impacts (WICCI 2011)

California Climate Adaptation Strategy (CAS) (CNRA 2009)

4.1 Agriculture

Agricultural production is the predominant land use on the American landscape. Virtually all crop (390 million acres) and pasture land (119 million acres), as well as a large fraction of rangeland (409 million acres), is privately owned by more than two million landowners and provides a livelihood to them and those who rent from them. Climate change aside, grassland species in the United States will feel more pressure over the next century as food production responds to greater demand from a larger global population and as farming technologies expand the range for planting annual crops both north and west. Further changes can be expected when drought, flood, or other climatic disruption affects crop production in Australia, Asia, or South America in the future. A successful climate change adaptation strategy for grassland species must contend with the global market forces and the associated policy responses that generate the returns to agricultural production. This represents a more formidable challenge than adapting public lands management to respond to a new stressor.

Irrigated agriculture relies heavily on surface-water diversions and groundwater pumping. Projected climate changes include less snowpack which would mean less natural springtime replenishment of water storage in the surface-water reservoirs.

JOHN CURLEY

Agricultural production is an economic activity that is uniquely sensitive to changes in precipitation and temperature and these agronomic factors are predicted to be more variable in a changing climate. Producers and governments will seek to mitigate the increased risk of shortages due to crop failure by increasing or encouraging increased production. If new technology or more nutrients and water cannot be used to satisfy increasing demand for food, open space will be used with increasing intensity for agricultural production, with pastureland converting to cropland, rangeland to pastureland and cropland, and retired marginal land to all three agricultural land uses. Expanding crop production in this way will likely increase pressures on plant and wildlife species that may also be confronting pressures resulting from a changing climate. Given the managed nature of agricultural lands and the likely expansion of cropland into grassland areas, it is critical to identify strategies to aid plant and wildlife adaptation in agriculture-dominated landscapes.

Maintaining viable grassland species populations requires adopting more wildlife friendly agricultural practices, managing the intensity of agricultural production, and selectively retiring some lands from production. Existing programs offer incentives for producers. For example, the Environmental Quality Incentives Program offers cost share for wildlife friendly livestock fencing. Other practices, like haying and grazing systems that have schedules sensitive to bird nesting seasons and integrated pest management, can make crop production more compatible with wildlife and pollinators.

Using long-term contracts and permanent easements, other programs encourage landowners to take and keep land out of crop production when doing so confers large conservation benefits. Two programs that are particularly relevant to grasslands are the Grasslands Reserve Program (GRP) and CRP. The former offers annual contract payments or lump-sum easement payment to landowners who want to maintain or enhance viable grasslands and the latter offers annual contract payments to landowners who convert cropland to grassland. Long-term contracts are particularly well-suited to climate change

concerns because they can be used as "rolling easements," permitting the landscape configuration of habitat to evolve over time. The CRP has been credited for providing habitat and increasing populations of waterfowl and grassland birds that had seen long-term population declines prior to the program. Both programs employ critical elements of climate adaptation strategies such as outreach, technical assistance, and financial incentives to help landowners restore and conserve grassland ecosystems and help to mitigate the effects of climate change.

Adaptation strategies for agriculture also benefiting natural resources

- » Encourage producers to take sensitive lands out of crop production for extended periods of time and restore wildlife habitat on these lands.
- » Encourage producers to maintain grassland habitat.
- » Encourage producers to adopt agricultural production and land use strategies that are resilient under changing conditions and that benefit agriculture, fish, and wildlife.
- » Improve estimates of ecosystem services to better link conservation compensation with the environmental services producers provide.
- » Encourage producers to adopt wildlife-friendly practices.

CASE STUDY

Lesser prairie-chicken in a changing climate

THE LESSER PRAIRIE-CHICKEN, which resides mainly in the grasslands of the southern Great Plains region, is a species in trouble. The conversion of native rangelands to cropland, decline in habitat quality due to herbicide use, petroleum and mineral extraction activities, and excessive grazing of rangelands by livestock have all contributed to a significant decline in population leading to its Candidate status under the federal Endangered Species Act (NRCS 1999).

Climate change is expected to make the bird's plight worse. Climate change models project that temperatures in the lesser prairie-chicken's range will climb by about 5 °F and that precipitation will decrease by more than one inch per year by 2060 (USGCRP 2009). Such changes would likely harm the lesser prairie-chicken's chances of survival.

GREG KRAMOS / USFWS

The good news is that simple management steps can make a big difference. Under existing USDA conservation programs, farmers and ranchers are compensated to take land out of production to create wildlife habitat. In fact, a landscape-scale geospatial analysis has shown that restoring native prairie grasses and sagebrush on 10 percent of land enrolled in CRP, if properly targeted, could offset the projected population decline of lesser prairie-chicken from climate change (McLachlan et al. 2011).

4.2 Energy

Climate-related changes to fish and wildlife habitat will occur simultaneous to changes that are occurring in the energy sector. Some of these changes will have clear implications for energy production and use (CCSP 2007). Energy usage patterns are expected to change in the United States, as are population demographics that drive regional energy demand and seasonal energy needs for heating and cooling (CCSP 2007, USGCRP 2009). For instance, average warming can be expected to increase energy requirements for cooling and reduce energy requirements for heating (USGCRP 2009).

In addition to challenges in managing consumer demand for electricity, particularly during peak load periods, changes in the physical environment may affect existing generation capacity and constrain the siting of new energy generation capacity (CCSP 2007). For example, changes in precipitation and snow pack will affect the seasonality and overall generating capacity of hydroelectric power, and decreased freshwater availability and increased surface water temperatures will affect water-cooled thermoelectric power plants in some regions (USGCRP 2009). Coastal power plants in some regions could be subject to climate-related impacts from erosion, inundation, storm surges, and river flooding as sea level rises and precipitation increases, especially during severe weather events (USGCRP 2009). Changes in the intensity or frequency of severe storms could also affect the reliability of transmission infrastructure (CCSP 2007, USGCRP 2009).

USFWS/RACHEL MOLENDA

Development of more efficient clean sources of energy remains a challenge, but is becoming increasingly important in a changing climate.

Changes in the production and use of fuels for transportation, heating, and cooling must also be considered, including the increased production of biofuels. Coastal (and offshore) facilities and infrastructure for producing and distributing liquid transportation fuels could be subject to similar impacts as coastal power plants (CCSP 2007, USGCRP 2009). Changes in population demographics could also affect levels of consumption and the location of infrastructure associated with the delivery of fuels (CCSP 2007).

Decisions made within the energy sector affect fish, wildlife, and plants, as do decisions in the natural resource management sector affect the energy sector. There is considerable uncertainty as to how many species of fish, wildlife, and plants will respond to climate change effects. The migration of species, particularly those listed as threatened or endangered, or the change in status of currently healthy populations under future environmental stressors, could affect the operation and siting of existing and new energy infrastructure. The sources of energy that are used influence the rate of GHG emissions, as well as the level of stress placed on local fish, wildlife, and plant populations along the supply chain. For this reason, it is important that efforts within the energy sector and natural resources management sector are better informed.

Adaptation strategies for energy development also benefiting natural resources

- Increase consultation and better align natural resource management and energy sector climate change adaptation strategies and activities, including vulnerability assessments.
- Incentivize the siting of new large energy projects in previously disturbed areas or areas that have the least impact to fish, wildlife, and plants. Avoid areas of high ecological vulnerability and areas with limited water availability and competing water demands.
- Research and develop energy technologies that minimize climate change impacts to fish, wildlife, and plants.
- Use local and regionally appropriate approaches that incorporate adaptive management principals to develop and site renewable energy resources to reduce vulnerability and enhance the resilience of local and regional ecosystems.

4.3 Housing and Urbanization

Since U.S. cities, towns and communities developed with an assumption of relatively stable climatic conditions, many U.S. municipalities and urban centers are at risk from the changing climate. This risk is exacerbated by a burgeoning urban population; 80.7 percent of the U.S. population now resides in urban areas, an increase of 12.1 percent since 2000 (U.S. Census Bureau 2012). Further, 30 percent of the U.S. population lives in a "coastline county"—and population along coasts continues to increase (U.S. Census Bureau 2010). Sea level rise and changes in temperature, precipitation, and extreme weather events will have the greatest impact on society and urban centers. Physical damage from storms, flooding, and sea level rise will threaten infrastructure and development, particularly along the coast. Changing temperatures and precipitation patterns will affect the built environment as well as resource availability (e.g., water). Increased temperatures and forest fires will reduce air quality and threaten life and property (McMahon 1999).

Human responses to climate change in the urban environment will likely include both fortification and relocation, impacting wildlife and natural systems in a variety of ways.

Human responses to climate change in the urban environment are expected to take one of two general paths: fortification or relocation.

Human responses to climate change in the urban environment are expected to take one of two general paths: fortification or relocation. Each of these broad strategies will affect fish, wildlife, and plants in a number of ways. In response to rising sea levels and extreme precipitation events, communities may develop engineered structures, such as seawalls and levees, to protect critical assets from potential inundation. These strategies, in turn, may adversely affect surrounding landscapes, resulting in habitat loss, and the inability of fish, wildlife, and plants to respond to climate-based stressors. In the longer term, human populations will likely shift to areas with ample natural amenities while people that remain in areas without necessary resources will exert more effort to import those resources (CCSP 2008a). The shifts in human population and the use of resources can be expected to strain the ecosystem services provided by the natural environment. Increased human demand for water resources will likely reduce water availability for fish, wildlife, and plants.

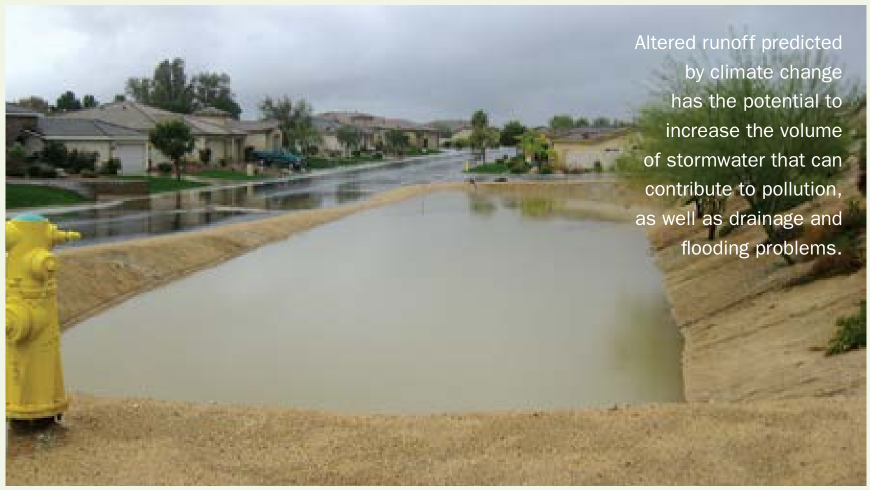
The availability of culturally, commercially, and recreationally important species for human uses (e.g., fishing, hunting, watching) will also change as species distributions respond to a changing climate and human population pressures. Availability of those species will ultimately affect subsistence and commercial use, recreation, tourism, and the economy. Also affecting the economy will be the response of harvestable resources (e.g., timber, fish) to a changing climate. Decisions made regarding development can affect fish, wildlife, and plant populations by reducing habitat availability, fragmenting habitats, and increasing multiple stressors. And conversely, development will be affected by the presence of species listed under the ESA, the number of which will likely grow due to climate change.

Adaptation strategies for community planning also benefiting natural resources

- Provide opportunities to engage many different stakeholders in land use and resource use decisions that incorporate climate change considerations.
- Anticipate changes in human demographic patterns in response to climate change, identify potential conflicts with the protection of fish, wildlife, and plants, and develop possible solutions.
- Continue current research on the valuation of ecosystem services so that communities can make better-informed decisions regarding land use and resource protection.
- Educate the public about ecosystems, ecosystem services, and anticipated climate changes, and prepare the public for projected changes.
- Develop multi-objective strategies to identify landscapes which sustain ecological values and provide human benefits through ecosystem services (e.g., urban green space which provides recreational and cooling values; restoration of native habitats and species; and promotion of native and drought tolerant species in development standards).
- Provide tools and methods that encourage communities to analyze the potential costs and benefits of adaptation strategies (i.e., fortify, accommodate, relocate) and their impact on surrounding habitats.
- Incorporate habitat migration potential into land-use planning and protect key corridors for species movement.
- Review federal programs to encourage buyouts and other mitigation measures in areas vulnerable to recurring climate change impacts.

CASE STUDY

Stormwater runoff



Altered runoff predicted by climate change has the potential to increase the volume of stormwater that can contribute to pollution, as well as drainage and flooding problems.

RAYMOND SHOBE

A MAJOR SOURCE OF POLLUTION related to development along the coastline is stormwater runoff. Runoff degrades water quality, making it an important stressor affecting resilience and sustainability of coastal habitats and species. As a result of increasing development, impervious surfaces that do not allow rain to penetrate the soils (such as parking lots, roads and rooftops) increase the amount, peak flow, and velocity of stormwater runoff, carrying pollutants into waterways and scouring streambanks. Changing precipitation patterns, especially increased frequency and intensity of heavy rains, will have a compounding effect on the amount of stormwater released into surrounding ecosystems.

Many tools are being developed to help land managers make informed decisions. For example, The National Oceanic and Atmospheric Administration's National Centers for Coastal Ocean Science at Hollings Marine Laboratory has developed a stormwater runoff-modeling tool to project the local impacts of development in a changing climate (Blair et al. 2011). Urbanized watersheds were compared with less-developed suburban and undeveloped forested watersheds to examine the relationship between land-use change and stormwater runoff and how this will be amplified under climate change.

This user-friendly and flexible tool provides a mechanism to quantify the volume of runoff and peak flow estimates under different land use and climate change scenarios. It provides an improved understanding of the impacts of development on stormwater runoff as well as the potential impacts associated with climate change in urbanized communities. Moreover, this research provides coastal resource managers with a tool to protect coastal habitat resiliency from both non-climatic stressors such as development as well as climate-associated stressors such as changing patterns of precipitation.

4.4 Transportation and Infrastructure

Transportation planners, owners, and operators face many of the same impacts and challenges of climate change as natural resource managers. Impacts of particular concern include rising sea level as well as increases in very hot days and heat waves, Arctic temperatures, intense precipitation events, and hurricane intensity (CCSP 2008b). While climate change poses threats to existing infrastructure, a changing climate likely will create new opportunities for increased Arctic transit or reduce operational costs for snow removal and maintenance.

Climate change will need to be considered in future infrastructure design, as projects are designed to stand the test of time and are built with long timeframes and local conditions in mind. Thus, it is necessary to understand how the impacts of climate change on local conditions are expected to change during the project's lifetime. Early and coordinated planning can allow transportation professionals and natural resource managers to design systems such that the goals of both can be met given a changing climate.

Natural resource and transportation agencies would benefit from increased collaboration on anticipated changes in flora and fauna patterns and potential ways to address them. Regional habitat conservation plans and strategies developed by resource agencies would provide information and a better understanding of the types of species that will be supported in the future. For example, if a transportation project is initiated with a lifetime of 20 to 40 years, advice and information from natural resource agencies is needed to ensure the right plantings for the future climate, not just current native species. These conservation plans and strategies would be used by Metropolitan Planning Organizations and state Departments of Transportation, airport planners and other transportation agencies in the development of transportation plans to avoid potential ecosystem impacts, allow advanced planning to minimize or avoid impacts, and to promote habitat resilience. Transportation agencies also could use these conservation strategies in the project development process to mitigate project effects in a more predictable, effective, and efficient manner.

The use of advanced conservation strategies and conservation banks by transportation agencies should continue to be encouraged. However, when such advanced practices are deployed, natural resource and transportation agencies should collaborate on sharing and identifying changing land use patterns to best inform locations for advanced conservation and banking decisions.

Natural resource and transportation agencies should work together to develop best practices that address the potential to use bridges, culverts, and roadway design to mitigate specific impacts such as sea level rise, precipitation, and stormwater on flora and fauna. For example, one method to deal with more intense precipitation events and resulting flooding is to increase the diameter of culverts. Larger culverts can, in some cases, also help to improve the ability of the culvert to serve as a passage for mammals, amphibians, and fish. Where both goals are being considered, the passage requirements of various animals and the geometry and geomorphology of the given stream should be taken into account in culvert design. As another example, protecting barrier islands and wetlands benefits both the natural environment and also reduces the effects of storms on the land and transportation infrastructure (roads) and operations. The Transportation Research Board has recommended a number of operational and design adaptation strategies for transportation systems responding to a variety of climate impacts.

CASE STUDY

Interagency cooperative conservation

WHILE NOT APPLICABLE TO ALL transportation agencies, Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects is an example of one existing robust program approach to help address ecosystem and species conservation given a changing climate and offers a framework for achieving greater interagency cooperative conservation. Eco-Logical is an environmental review toolkit designed to help agencies join in partnerships as catalysts for greater stakeholder cooperation and coordination through promoting a Strategic Habitat Conservation and an ecosystem approach to species and ecosystem conservation, including the integration of climate change into the conservation strategy. It is goal driven, and based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries (Brown 2006).

RICHARD WASSERMAN

Lake Mead is the largest reservoir in the United States in maximum water capacity but severe drought has caused water levels to drop.

Adaptation strategies for transportation also benefiting natural resources

- Strengthen interagency and stakeholder cooperation and coordination, particularly between transportation and natural resource planners and managers.
- Identify changing transportation demands resulting from climate change and the implications to infrastructure development.
- Use the best available habitat conservation plans to develop strategies associated with transportation projects that take into account climate change impacts to habitats and species.
- Develop best management practices (BMPs) and best designs for transportation projects to accommodate climate change effects and incorporate conservation needs at the same time.

4.5 Water Resources

Water resources are shared by fish, wildlife, plants, and many different human interests (e.g., agriculture, drinking water, manufacturing, energy). The balance of use and consumption will ultimately determine the quantity and quality of water available for species and ecosystems. Already under stress from climate change, the nation's fish, wildlife, and plant populations would be further stressed by a lack of available, high quality water resources. All decisions made regarding water resources will have a direct influence on the quantity and quality of habitat that supports both aquatic and terrestrial species.

Many of the impacts described in Section 2.3.6: Inland Water Ecosystems apply to other aspects of water resource management beyond fish, wildlife, and plants. Rising stream temperatures, altered precipitation patterns, reduced snowpack and earlier snowmelt, and saltwater intrusion are expected to impact the management of water supply, water quality, and water use. Impacts on water resources will vary between regions, as precipitation is anticipated to increase in certain areas, decrease in others, and overall become more variable with more severe drought and heavier rainfall, often occurring in the same area. Past water levels and precipitation patterns will no longer serve as indicators of future conditions as climate change creates conditions outside of historical parameters (CCSP 2008d).

Climate change impacts and adaptation needs for the water resources sector are described in much more detail in the recently published *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate* (hereafter *Freshwater Action Plan*) (ICCATF 2011), which establishes 24 priority actions for federal agencies in managing freshwater resources in a changing climate. The *Freshwater Action Plan* identifies "ensuring adequate water supplies; protecting human life, health, and property; and protecting the quality of freshwater resources" as major challenges (ICCATF 2011). The water resources management community can build resilience to both climate and non-climate stressors by using strategies that incorporate green infrastructure and watershed-based approaches that use the ecosystem services provided by fish, wildlife, and plants. Living resources can also serve as bio-indicators of water quality or perform biofiltration, thereby improving local water quality and increasing the value of those water resources. Additionally, riparian zones and wetlands have been shown to improve water quality, reduce flooding, and sequester CO_2.

The *Freshwater Action Plan* (ICCATF 2011) provides the following recommendations that can assist the water resources sector in ensuring the continued protection of fish, wildlife, and plant resources:

Adaptation strategies for water resource management also benefiting natural resources

- Establish a planning process that includes multiple levels of government, prioritization of challenges, and considerations for other resources.
- Improve water resources and climate change information for decision-making to help move decisions beyond a reliance on past conditions.
- Strengthen assessment of vulnerability of water resources to climate change.
- Expand water use efficiency, conservation, productivity, and substitution to reduce overall demand of water.
- Support integrated water resources management through coordinated adaptive management.
- Support training and outreach to build response capability using cross-disciplinary education, instruction, and training while focusing on solutions integrated across multiple sectors.