ANNEX
THREE ILLUSTRATIVE EXAMPLES OF INTERACTIONS BETWEEN SDG 2 AND THE OTHER SDGS

Literature referred to in the texts may be found within the References section to the chapter on SDG2

THE COMPOUND CHALLENGES OF DEFORESTATION, FOOD AND ENERGY PRODUCTION FOR CLIMATE MITIGATION, ECOSYSTEM PROTECTION AND HEALTH IN THE AMAZON REGION

SUMMARY OF KEY TRADE-OFFS

Land use conversion for agriculture purposes such as cattle ranching or soybean production (2.3) **or biofuel production** (7.2) **may counteract the maintaining of ecosystems and forest conservation/protection** (15.1, 15.2, 15.5, 2.4)

Hydroelectric power generation (7.2), **can lead to the flooding of forested areas (especially constraining** 15.2) **and a decrease in agricultural productivity in the lowland Amazon floodplains (SDG2)**

Deforestation due to intense agriculture/pasture expansion, can counteract efforts to combat climate change (SDG13) and constrain climate adaption by increasing climate instability and extreme events (13.1). **Such a trend may be exacerbated by dams which also lead to an increase in greenhouse gas emissions**

Land use conversion for agricultural purposes (2.3) may constrain SDG3 due to an increase in exposure to malaria risk (3.3) **and/or mercury contamination of soil** (3.4, 3.9)

The Amazon is a typical example of a 'frontier economy' (Boulding, 1966) where economic growth, based on the perpetual conquest of land and resources, is sometimes seen as infinite (Becker, 2005). Deforestation to provide land for agriculture, cattle ranching and large-scale hydropower generation has been the prevailing model for rural development over the last 50 years (Nobre et al., 2016). In Amazonia, smallholder farmers play a critical role in the maintenance of global agrobiodiversity, and generally use few agro-chemicals (Kawa et al., 2015), but were responsible for up to 69% of Amazon deforestation between 2006 and 2011. Deforestation declined between 2004 and 2012, but increased sharply in 2016.

THE NEXUS FOOD-WATER-ENERGY-DEFORESTATION

Much of the total deforested area in the Brazilian Amazon (legal Amazonia) has been converted to pasture for cattle ranching, approximately 70–88% in 1995 (Margulis, 2004) and 62% in 2008 (Almeida et al., 2016). For Mato Grosso State, increased soybean production between 2000 and 2007 accounted for 12% of the deforestation, with 71% of newly cultivated soybean fields planted in formerly deforested areas. Since 2009, 46% of the increase in agricultural production was achieved through changes in agricultural management practices (Arvor, 2009). The effect of biofuel production on deforestation has not been assessed globally, but biodiesel from soybean in Mato Grosso may have been responsible for up to 5.9% of the direct annual deforestation over the past few years (Gao et al., 2011). On 24 July 2006, the Soybean Moratorium was signed, which effectively reduced the deforested land for soybean production. Since first agreed, the moratorium has been renewed every year, and it is currently renewed without end date (Greenpeace, 2016). Land use change pressures can be further reduced by investing in second generation biofuels and public transport, with positive impacts for the Brazilian economy (Obermaier M., pers. comm.). Large parts of the Amazon are suitable for palm oil production and profitable (Englund et al., 2015). Lack of interest in sustainability criteria in key consumer markets may worsen production standards in Brazil, including social sustainability of rural workers on the plantations. This illustrates the competition over land use and trade-offs between SDG2 (mainly the targets emphasising agriculture productivity improvement, such as 2.3) and the need to halt deforestation (**15.1, 15.2, 15.5**).

Intense agriculture based solely on short-term productivity without sustainability may counteract SDG targets related to forest conservation/protection. This negative interaction also illustrates the potential conflicts between the various SDG2 targets, where unsustainable agriculture productivity (**2.3**) may constrain the maintenance of ecosystems (**2.4**). Negative interactions of this type are exacerbated by biofuel production as a means of increasing the share of renewable energy in the energy mix (**7.2**).

Biofuel production is one of the strongest links between agriculture, deforestation and green energy (Kahn et al., 2014). Hydroelectric power generation is another. The Brazilian plan calls for 30 new large dams in the next 30 years (Brazil MME, 2011). This would cause the flooding of 12,000 km^2 of forested area (Fearnside, 2000). Apart from a significant increase in GHG emissions, well known in tropical countries (Kemenes et al., 2007), one of the consequences will be decreased productivity in the lowland Amazon floodplains due to the retention of nutrients by reservoirs. This endangers food production, because floodplains contain most of the traditional agriculture, coupled with fishing livelihoods (fish disappear after dam construction), hunting and forest product gathering, with major seasonal variations driven by the annual flood cycle, also affected by the dams (Barham et al., 1999).

In this case, water use to increase the share of renewable energy (**7.2**) via hydroelectricity, may also counteract the maintaining of ecosystems (**2.4**) and the pursuit of forest conservation/protection (**15.1, 15.2, 15.5**) and also constrain the capacity to reach food and nutrition security (**2.1, 2.2**) as well as the capacity for small-scale food producers to increase their food production and revenues (**2.3**).

CONSEQUENCES FOR CLIMATE CHANGE

Converting forest to pasture is estimated to result in an average temperature increase of 1.0–1.5°C in deforested area during the dry season due to the change in surface energy budget (Gash et al., 1996). Deforestation due to intense agricultural expansion highlights how **target 2.3** can counteract combatting climate change and can constrain climate adaption by increasing climate instability and disasters (**13.1**).

The impact of land use change on precipitation is not clear and needs further study. A possible explanation for the precipitation reductions observed in the last two decades over the southern and south-eastern Amazon could be the change in albedo between forests and pasture. In all countries with a large part of territory belonging to the Amazon (Brazil, Columbia, Peru, Bolivia, Ecuador), agriculture, forest and land use change account for over 83% of total GHG emissions. These countries rely heavily on agriculture and forestry for climate change mitigation (Börner and Wunder, 2012). However, mitigation solutions in these sectors imply a high level of technological complexity. Less demanding technology solutions to mitigate GHG emissions such as land retirement and primary forest conservation do exist but involve higher implementation costs for smallholdings than for medium to large farms.

CONSEQUENCES ON BIODIVERSITY STOCK DEPLETION

A study in the southwestern Amazon, indicates that post-logging timber species composition and the total value of forest stands do not recover beyond the first-cut, suggesting that the most valuable (in commercial terms) timber species become rare or even disappear in old logging frontiers (Richardson and Peres, 2016).

Intense agriculture expansion may thus constrain the achievement of SDG15 on biodiversity, and may in particular counteract **target 15.5** on the reduction of habitat degradation, halting the loss of biodiversity and the extinction of threatened species.

Aquatic biodiversity will decline as a direct result of Amazonian dam projects due to the loss, fragmentation and degradation of riparian and terrestrial habitats (Lees et al., 2016).

IMPACTS ON HEALTH

In the Tapajos Amazon region, conversion of forest to pasture results in soil erosion and the transfer of soil sediments into waterways, causing mercury pollution. Inorganic mercury, which is naturally present in the soil, is then transformed into methylmercury through bacterial activity and enters the aquatic food web, with the highest mercury concentrations occurring in the top predators at the ends of food chains. The majority of riverside dwellers eat fish several times per week. Methylmercury is a neurotoxin, and various studies have reported nervous system dysfunction associated with mercury exposure among these communities (Fillion et al., 2009). This example shows how land conversion for agriculture purposes aligned with t**arget 2.3** may constrain health, particularly the reduction of deaths and illness caused by hazardous chemicals **(3.9)** and the fight against non-communicable diseases **(3.4)**. A recent study on the border between Brazil and French Guiana summarised the links between land use change and an increase in exposure to malaria risk: deforested areas provide favourable conditions for malaria vector breeding and feeding, while forest and secondary forest can provide resting sites for adult mosquitoes after feeding. Consequently, the more the forest and secondary forest patches interact with deforested patches, the more the landscape is favourable to vectors and vector-human encounters (Li et al., 2016). This trend illustrates how deforestation for the purposes of conversion to another type of land use such as agriculture can counteract the ending of communicable diseases such as malaria **(3.3)**.

PUTTING SUSTAINABLE LAND MANAGEMENT AT THE HEART OF SENEGAL'S NATIONAL DEVELOPMENT STRATEGY

SUMMARY OF KEY SYNERGIES

Sustainable land management and improving land and soil quality (SDG2) can:

Reduce land degradation/ desertification and increase fertility and biodiversity protection (15.3)

Reduce soil erosion and maintain the physical structure of the soils and thus their water-holding capacity as well as regulating soil quality (6.6)

Sequester carbon and mitigate climate change (SDG13). Such co-benefit impact contribute to SDG2 food security targets as sequestered carbon, when mineralised, releases nutrients for plants

Play a major role in food security and poverty alleviation in urban and peri-urban areas (1.1, 1.2)

Summary of key trade-offs

Depending on soil quality, improving plant production may counteract action on climate change (SDG13)

Some agriculture practices can have adverse impacts on terrestrial ecosystems (SDG15). Strong international partnerships and capacity-building are key to mitigating such trade-offs (SDG17)

Intensive peri-urban agriculture using fertilisers and pesticides to increase productivity and therefore farming revenue (2.3) **constrains water quality** (6.1, 6.3) **and increases associated diseases** (3.9)

BACKGROUND

As is the case in many African countries, the population of Senegal is growing rapidly. Population is expected to triple between 2013 and 2050. This rapid growth is indicative of a marked demographic transition that is increasing demand for goods and services, and increasing pressure on natural resources and the environment.

Senegal is currently the second fastest growing economy in West Africa, behind Côte d'Ivoire (World Bank, 2017). In 2015, GDP grew by 6.5%, which had not been achieved since 2003. The fastest growing sector is the primary sector, boosted by growth in extractives, fishing, and agriculture. Exports from the primary sector are increasing rapidly.

West Africa suffered a long period of low annual rainfall between 1968 and 1998. This significantly reduced the availability of surface water and the recharge of groundwater, resulting in saltwater intrusion in the main coastal basins. However, the situation has now reversed, and average rainfall for the period since 2006 is greater than the average recorded for the period 1940–2012. According to the Senegalese Directorate of Management and Planning of Water Resources, water resources are now adequate in rivers, watercourses and underground. However, distribution and management of these resources are unsatisfactory. Less than 50% of the water available in the Senegal

River is estimated to be used for irrigated agriculture.

Climate models project that by 2050 average temperature in Senegal will have increased by 3–4°C. The greatest changes in rainfall are projected to occur in semi-arid regions. Rainfall during the cropping season is projected to drop by 20%, with the rainy season ending earlier (Sultan and Gaetani, 2014).

AGRICULTURE

Agriculture plays an important role in the national economy. It is the main economic activity in rural areas of Senegal. In the country as a whole, 60% of the working population is employed in agriculture. However, agriculture accounts for only a small proportion of GDP (8%).

LAND DEGRADATION

By ratifying the United Nations Convention to Combat Desertification in 1994, Senegal undertook to implement a National Action Plan (NAP). In its third report, the Ministry for the Environment and Nature Protection (Ministère de l'environnement et de la protection de la nature, 2004) assessed land degradation in Senegal, and showed that almost 60% of arable land was subject to degradation, mainly related to water scarcity and water erosion. Despite considerable investment efforts to implement the NAP, the report revealed that degradation had continued, increasing poverty.

NEXUS OF LAND DEGRADATION, FOOD SECURITY, CLIMATE AND WATER CHALLENGES

In 2014, Senegal adopted "a new development model to accelerate its progress toward emerging market status [which] constitutes the reference for economic and social policy […]" (Ministry of Economy, Finance and Planning, 2014: Executive Summary). In the agricultural sector, the successful implementation of priority actions, such as water management, improving soil quality and land reform depends on several factors. At the same time, by ratifying the Paris Agreement within the United Nations Framework Convention on Climate Change, Senegal undertook to reduce its global GHG emissions, some of which were generated by the agriculture sector, and to implement adaptation measures such as technologies to combat land degradation and access to drinking water.

SUSTAINABLE LAND MANAGEMENT: THE MANY BENEFITS PROVIDED BY SOIL ORGANIC MATTER

Soils provide many ecosystem services that are essential to communities and their environment. The role played by organic matter in soil functioning has now been clearly established (Feller et al., 2012; Banwart et al., 2014): it maintains fertility, assures primary production and maintains the physical structure of the soils and thus their water-holding capacity as well as regulating soil quality (SDG6). As the main carbon sink of terrestrial ecosystems, soils also regulate the exchanges of carbon dioxide and other GHGs between the soil and the atmosphere. Increasing organic matter stocks, therefore, helps to mitigate climate change (SDG13). However, it is also important that some of the organic matter stored in soils should be mineralised to ensure the release of nutrients, such as nitrogen, for plants, thus improving productivity (SDG2). Recent research (e.g. Wood et al., 2016) showed that different forms of soil organic matter do not have the same magnitude of effects on climate change mitigation or crop yield. There is, therefore, a trade-off between actions required to mitigate climate change (SDG13) and actions required to improve plant production (SDG2). Anticipating the impact of action plans on the targets associated with these two goals requires a detailed knowledge of the processes that determine soil organic carbon dynamics. Such knowledge can help to reinforce synergies within the nexus and mitigate or even overcome some constraints and trade-offs between the goals.

In West Africa and Senegal, sustainable land management is the core issue of action plans to combat land degradation. These plans focus on water management (SDG6), fertility and biodiversity (SDG15) (Liniger et al., 2011). In these regions, the viability of production systems depends to a great extent on the management of organic residues (crop residues, manure, etc). In savanna regions, production systems are organised as a ring around the villages (Manlay et al., 2004) with a gradual increase in intensification from the savanna area towards the centre of the village. This spatial organisation and the recycling of organic residues are key for soil organic matter stocks (Manlay et al., 2004). Because regions with sandy soils have a low storage capacity, increasing productivity should be the priority target of agricultural action plans. In 2010, the Senegal Ecological Monitoring Centre, together with its partners, published a set of best practices for sustainable land management in Senegal (CSE, 2010). This showed the diversity of existing practices, highlighting the potentially harmful effects of some practices on other aspects such as biodiversity (SDG15). Although these best practices exist, Botoni and Reij (2009) stressed that upscaling them requires a strong international commitment (SDG17: Strengthen the means of implementation and revitalise the global partnership for sustainable development) and the use of dedicated funds to fully meet the multiple challenges of combating land degradation, ensuring food security, water management and mitigation of, and adaptation to, climate change.

GOVERNANCE OF LAND TENURE: A SAFEGUARD TO AVOID HARMFUL IMPACTS

According to the FAO, "The eradication of hunger and poverty, and the sustainable use of the environment, depend in large measure on how people, communities and others gain access to land, fisheries and forests" (FAO, 2012: Preface). De Schutter (2011) pointed to the need for security of land tenure to ensure national food security, and stressed the importance of not transposing the Western model of property rights to resolve competition for land between local communities and companies willing to invest in agriculture in developing countries.

To meet this challenge of rational land governance, Senegal has drawn up Land Occupation and Use Plans, for example for the Lac du Guiers region (see http://ppr-srec.org/fiches-actions/observatoire-participatif-de-veille-sur-le-foncier-opvf-phase-pilote-dans-la-zone-du-lac-de-guiers-au-senegal.html).

SOCIAL AND ENVIRONMENTAL LINKS BETWEEN URBAN, PERI-URBAN AND RURAL AREAS

In 1976, 34% of the population in Senegal lived in cities (République du Sénégal, 2014). By 2013, this had increased to 49%, with around 50% of this urban population concentrated in Dakar. Urbanisation has thus accelerated during recent decades. There are many complex factors explaining the increased number of people living in cities in Senegal. However, Gueye et al. (2015) showed that drought has had a major impact on migration to cities. Successive droughts (1970–1973, 1976–1977, 1983–1984) had an almost immediate effect on the economy of Senegal, which is largely based on agriculture (peanuts, millet, rice, cowpea, manioc, etc), with the migration of rural populations to cities which were forced to accommodate these new inhabitants in a short space of time. Farmers, accounting for a very high proportion of these new arrivals, helped to develop peri-urban agriculture, thus meeting the increased food demand in cities. Peri-urban agriculture is a source of revenue for the poorest households in urban areas (Golhore, 1995). It therefore plays a major role in action to end poverty (**1.2**). In Senegal, a 250% increase in production is forecast with an increase in the area under cultivation (Gueye et al., 2015). However, this peri-urban agriculture model has a detrimental effect on population and human health (Ba et al., 2016). Research undertaken in the large metropolis of Dakar (in Pikine and Niayes) showed that developing intensive peri-urban agriculture using fertilisers and pesticides to increase productivity and, thus revenue from farming **(2.3)**, had a detrimental effect on water quality **(6.3)** and drinking water **(6.1)**. In a study of more than 100 wells in the Niayes area, Sall and Vanclooster (2009) found the water was severely polluted by nitrates and so called for the rapid implementation of environmentally-friendly farming practices to ensure sustainable production (SGD12). In these peri-urban farming systems, efforts to increase production currently tend to degrade water quality. This harmful interaction constrains the achievement of **target 3.9**. A survey of the market-gardening systems in Pikine (a suburb of Dakar) showed that nearly 7% of produce (lettuce) was contaminated by Salmonella, a human pathogen (Ndiaye et al., 2011).

IMPLEMENTING CLIMATE SMART AGRICULTURE TO ADDRESS CALIFORNIA'S WATER CHALLENGES

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SUMMARY OF KEY SYNERGIES

Access to nutritious food (2.1) **contributes to ending malnutrition** (2.2)

SUMMARY OF KEY TRADE-OFFS

Agricultural production can reduce air quality (3.9)

Nitrate leaching from fertiliser use and animal production contaminates drinking water (6.1)

Fertilisers and animal waste run-off may pollute surface water (6.3)

Agriculture is a major user of freshwater, challenging sustainable water withdrawal and supply (6.4)

California is among the top ten agricultural economies globally and the largest in the USA, with an estimated US$ 50 billion per year in farm-gate revenue. While agriculture, together with food and beverage processing, accounts for less than 5% of the overall state economy, it continues to play a significant role in rural incomes. California agriculture is highly market-orientated, with continued shifts toward high value products that take advantage of the Mediterranean climate and can compete globally on quality and safety, which is evident through its 23% share in total export revenue.

With over 76,000 farms ranging from small, organic to large commercial operations, producing over 400 different agricultural commodities, California plays an important role in providing access to safe and nutritious food to end malnutrition in all forms (**2.1, 2.2**) and ensuring sustainable and resilient food systems (**2.4**). Achieving these, presents both synergies (reinforcing) and trade-offs (constraints) to meeting other SDGs. As California has one of the strongest records on environmental regulation in the USA, its policy approaches to minimising trade-offs between agriculture and environmental objectives may be instructive.

NUTRITION AND HEALTH: SDG2 & SDG3

California is responsible for almost half the U.S. production of vegetables, fruits, and nuts, and 20% of dairy products. Thus, California's agriculture plays a very significant role in the nutritional quality of the U.S. diet, reinforcing access to safe and nutritious food (**2.1**) and ending malnutrition (**2.2**). However, Californian agriculture also poses constraints on other health targets. Farm activities account for 21% of ozone-forming gases and more than half of particulate emissions (from fertilisers and dust) in the San Joaquin Valley (Cowan, 2005; ARB, 2008). This constrains reducing the number of deaths and illness from hazardous chemicals and air, water, and soil pollution and contamination (**3.9**). Californian air pollution laws had exempted farms from permitting requirements until 2004, when a series of new regulations on farms, wine fermentation, and large cattle and dairy operations began requiring state pollution permits to address this trade-off. Finally, agriculture constrains access to clean drinking water, a health concern being addressed through regulatory measures.

SUSTAINABLE & RESILIENT AGRICULTURE: SDG6 - WATER

With a dry climate, water is an essential resource for agricultural productivity and climate resilience in California. During the current five-year drought, agriculture has received no or greatly reduced surface water allocations, leading to a negative economic impact on the agriculture sector amounting to US$ 2.2 billion in 2014 (Howitt et al., 2014; Medellin-Azuara et al., 2016).

With the Poter-Cologne Act of 1969, California began regulating water quality prior to the passage of the national Clean Water Act. State water quality regulations were further strengthened to reduce run-off from irrigated lands (in 2003) and improve groundwater quality (in 2001). However, nitrate leaching into groundwater in regions with intensive agricultural crop and livestock production leads to groundwaters that exceed drinking water quality standards (Harter et al., 2012). As many people outside large urban centres depend on wells for drinking water, agricultural practices constrain access to safe and clean drinking water (**6.1**) and improving water quality through reducing pollution (**6.3**). To reduce nitrate leaching from fertiliser use, policy responses being considered include increasing taxes on nitrogen fertilisers and increased regulatory measures in the form of grower nutrient management plans. To offset the impact of these measures on the economic sustainability of Californian agriculture, funding from taxes on fertiliser sales have been used since 1990 for research to assist farmers in reducing the environmental impact of fertiliser use. This research has resulted in recommendations and tools used by growers to sustain productivity and facilitate compliance with water quality regulations.

Competition across urban, environmental, and agricultural sectors has intensified with increased environmental priorities and the needs of growing urban populations, along with periodic droughts. Of the total estimated surface water available, from runoff stored in reservoirs and from stream flow, agriculture withdraws 40%, while the environment accounts for 50%, with the urban sector accounting for the remaining balance (California Department of Water Resources, 2013). In normal water years, about 70% of developed water use (surface + groundwater) is for irrigated agriculture. However, in periods of drought, less water is allocated to irrigation districts and the share of irrigation water declines to 50% or less. In normal years, about one third of total developed water is from groundwater; the level increases to 50% or more in periods of drought such as in the last few years. Increased reliance on groundwater constrains ensuring sustainable withdrawals and supply of freshwater to address water scarcity **(6.4)**. It also constrains access to clean drinking water **(6.1)**. In 2016, the State was forced to allocate US$ 19 million to provide emergency drinking water to thousands of people, largely in agricultural regions, due to overdraft of groundwater wells. To address concerns over the sustainability of groundwater for both agricultural and drinking water needs, California passed the Sustainable Groundwater Management Act in 2014 to regulate groundwater pumping. The impact of this new law is not yet clear, but will clearly constrain agriculture in regions of the state that rely entirely on groundwater for irrigation. Thus, a potential impact is a reduction in state-wide crop acreage.

The relationship between agriculture and water resources is complex and requires action at both the farm and basin scale. During the past 50 years, the water use efficiency of California agriculture has increased: total agricultural water use has declined while at the same time, the shift toward higher value crops has significantly increased the productive use of that water. However, the shift toward more efficient drip and micro sprinkler irrigation systems which contributes to this efficiency gain, has simultaneously constrained sustainable groundwater management. Drip irrigation significantly reduces groundwater recharge rates, and the number of irrigated acres expanded as farmers shifted to groundwater supported drip and thus independence from canal infrastructure providing surface water. Research, funded by agricultural producer organisations such as the Almond Board of California, along with public sources, is examining the possibility of deliberately flooding agricultural lands in the rainy winter months to increase groundwater recharge, advancing new solutions to reinforce sustainable management of this critical resource.

SUSTAINABLE & RESILIENT AGRICULTURE: CLIMATE CHANGE - SDG13

The concept of Climate Smart Agriculture – balancing mitigation, adaptation, and productivity – is increasingly integrated into California's agricultural policy framework. While agriculture accounts for only 8% of state GHG emissions, it will, in turn, be significantly impacted by climate change. The projected reductions in precipitation and more frequent periods of drought are a major driver for adaptation. Furthermore, rising temperatures will significantly impact major crops: almonds and stone fruits require winter chilling, and wine grapes have climatic specificity for different varieties. The state passed a comprehensive climate change law in 2006 that called for reducing GHG emissions through the use of a cap and trade system. This policy has since been strengthened by additional regulations and investments in a low carbon economy, including in the area of agriculture. While the original policy did not set GHG emission caps on agriculture, it does regulate emissions from food and beverage processing in the state, thus connecting SDG13 with SDG2. In September 2016, the state enacted new regulations on short-lived climate pollutants to meet more ambitious climate mitigation goals. This regulation calls for methane reductions in the dairy production sector. Livestock production accounts for about half of California's agricultural emissions, with the majority of dairy production in large, confined operations. It is expected that the new methane emissions regulations could significantly constrain the economic viability of the dairy industry through very significant increases in costs associated with changing manure management practices (Lee, 2016). At the same time, the priority given to climate change in state policy has provided a framework for synergies with agricultural productivity and adaptation through public investments in incentives for growers to adopt climate mitigating practices. Funds from carbon credit auctions support incentives (subsidies) for growers in the areas of healthy soils, more water and energy efficient irrigation systems, and installation of dairy digesters. A recent review of research in California demonstrates that these technologies and management practices offer co-benefits for both GHG emission reductions and either productivity or climate resilience benefits (Byrnes et al., 2016), reinforcing the economic and environmental sustainability of agriculture. Thus, while the climate mitigation policy framework in the state may have some constraining impacts on agriculture, it also provides reinforcing investments in the productivity, sustainability, and resilience of the sector.

The case of California illustrates some of the approaches to reconciling across goals for an economically viable, highly diverse food system and a sustainable environment. Increased regulation for health and environmental concerns, more limited allocation of water for agriculture, and international trade competition constrain California agriculture and will continue to drive changes in the amount and types of agriculture produced. At the same time, investments by the state and national governments and agricultural producer organisations are providing incentives and new tools and technologies that are driving continuous improvement in the agriculture sector to reconcile these constraints between goals. This is evident in the continued growth in economic value of the sector and the increasing evidence of improvements against environmental measures.