AEM Tier 2 Worksheet
Greenhouse Gas Mitigation Opportunities

Glossary

Adaptation: Management changes to reduce risk and/or realize opportunities presented by climate change.

Anaerobic: Absence of oxygen.

Best Management Practices (BMPs): Conservation practices to control pollution.

Carbon Cycle: The global exchange of carbon among the atmosphere, oceans, vegetation, soils, and geologic deposits.

Carbon Dioxide (CO_2): The dominant greenhouse gas (GHG). It is emitted primarily from fossil fuel combustion, but also loss of soil organic matter and deforestation.

Carbon Sequestration: Storage of carbon in a biological or geological sink. Biological sinks are soil, trees, and oceans.

Climate Change: A significant change from one climate pattern to another. During recent decades human-induced climate change has occurred much faster than most previous natural climate changes.

Concentrated Animal Feeding Operation (CAFO): Animal feeding operation that (a) confines animals for more than 45 days during a growing season, (b) is in an area without vegetation, and (c) meets certain size thresholds.

Global Warming Potential: The potency of a particular greenhouse gas. The common unit is a carbon dioxide equivalent or CO2e. Methane (CH4) and nitrous oxide (N2O) have global warming potentials of 34 and 298 CO2e, respectively.

(Continued Page 2)

Background

Climate change caused by increased emission of greenhouse gases (GHG) to the atmosphere is an important issue that affects agriculture. Some agricultural practices emit GHG, while others reduce GHG emissions. Globally, agriculture is responsible for approximately 20% of annual GHG emissions (IPCC). In the United States, agriculture is responsible for roughly 8% of GHG emissions (US EPA). New York State accounts for 1% of the global total emissions, but agriculture only contributes an estimated 2% of the State emissions because of high emissions of GHG from non-agricultural activities. Nonetheless, agriculture in New York State can continue to advance management for reduced greenhouse gas emissions as a part of the global effort to curb climate change. For example, improving dairy diets has reduced enteric (methane-based) GHG emissions from dairy cows, and improved management of nitrogen fertilizer has reduced nitrous oxide emissions (a very potent GHG). Additionally, some agricultural practices have the potential to reduce GHG emissions from other sectors, such as bioenergy reducing emissions from electric generating stations.

Agricultural GHG emissions come primarily from three gases: methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). While CH_4 and N_2O emissions are much lower in volume than CO_2, these GHGs have a much greater ability to trap heat in the atmosphere. To simplify GHG accounting, each gas is assigned a value called the **Global Warming Potential** (GWP) that shows its ability to trap heat in the atmosphere compared to CO_2. The unit for GWP is the **carbon dioxide equivalent** (CO_2e). Over a 100-year period, methane and nitrous oxide are 34 and 298 times more potent than CO_2, so they have GWP values of 34 and 298, respectively.

AEM Principle:

Agricultural practices can reduce greenhouse gas (GHG) emissions while maintaining other valued services from farms, such as inexpensive food, scenic landscapes, habitat, stormwater management, economic development, and clean air and water.

Glossary continued …

Greenhouse Gas (GHG): Any gas that absorbs infra-red radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, halogenated fluorocarbons, ozone, perfluorinated carbons and hydrofluorocarbons.

Greenhouse Effect: Greenhouse gases allow radiation from the sun to pass through the Earth's atmosphere, but prevent most of the heat from the Earth's surface from escaping into outer space. Humans have increased greenhouse gases in the atmosphere and increased the greenhouse effect.

Intergovernmental Panel on Climate Change (IPCC): The IPCC summarizes the latest scientific, technical, and socio-economic information related to human-induced climate change, its observed and projected impacts, and options for adaptation and mitigation.

Methane (CH_4): A potent greenhouse gas that has a Global Warming Potential of 34.

Methane Destruction: Combustion destroys methane by turning it into CO_2 and water. Because methane has a GWP of 34, methane destruction decreases its GHG impact 34-fold. A covered earthen manure storage unit that flares biogas is an example of methane destruction.

Mitigation: Efforts to reduce or prevent emission of GHG.

Nitrous oxide (N_2O): An extremely potent greenhouse gas that has a global warming potential of 298.

Regional Greenhouse Gas Initiative (RGGI): An agreement made by 10 Northeastern States to cap emissions of GHG from electricity generation using a cap-and-trade program.

Weather versus Climate: Weather describes atmospheric conditions for a specific place and time (often short-term, like a day), while climate is the average of those weather conditions over long periods of time.

Background Continued…

In 2008, NYS expanded AEM by including greenhouse gases, air quality, and energy in its management and outreach scope. "There is hereby established within the Department an Agricultural Environmental Management program to assist farmers in maintaining the economic viability of their farm operations while addressing environmental impacts from those operations, including, but not limited to, soil, air and water pollution and greenhouse gas emissions." Sometimes managing for one resource is detrimental to another resource. This worksheet is aimed at identifying opportunities and tradeoffs when considering farm GHG emissions in the context of broader stewardship goals.

Topics Included

This worksheet is an introduction to key GHG mitigation opportunities on farms, but does not include all agricultural sources and sinks of GHG. It highlights six management areas that provide important opportunities to reduce GHG emissions using existing agricultural practices. Management areas include:

Dairy Feed Management
Manure Storage
Manure and Fertilizer Nitrogen Management
Forest Management
Soil Organic Matter Management
Energy Efficiency

The worksheet also indicates potential effects of management on other resources, including financial, water quality, air quality, habitat, etc., as well as a farm's ability to adapt to climate change. To use the worksheet, compare the water quality assessment rating taken from the referenced AEM Tier 2 worksheet with the rating generated for GHG mitigation in this worksheet and with potential impacts on adaptation to climate change and other areas of farm management.

Links to Tools and References

NRCS Climate Change Resource Page:
www.nrcs.usda.gov/wps/portal/nrcs/main/national/climatechange/

Cornell Institute for Climate Smart Solutions (CICSS): http://climateinstitute.cals.cornell.edu/

Climate Smart Farming: http://climatesmartfarming.org/

Carbon Trading: www.agcarbontrading.org

Animal Agriculture and Climate Change: https://animalagclimatechange.org

NY State Bill S8148/A10685:
http://assembly.state.ny.us/leg/?default_fld=&bn=S08148&term=2007&Summary=Y&Text=Y

AEM Tier 2 Worksheet: **Dairy Feed Management** **Greenhouse Gas Mitigation Opportunities**	**Potential Opportunity**

General Note: Improved dairy feed management increases nitrogen use efficiency and decreases enteric methane emissions. Additionally, the greater the feed efficiency, the less manure is produced per unit milk. With less manure there are fewer volatile solids and therefore less methane production and emission from manure management. There is also less nitrogen and therefore less nitrous oxide emission from manure.

WATER				
Overall Rating from Management of Dairy Feed Nutrients Tier 2	**Beneficial 1**	**2**	**3**	**Detrimental 4**
Water Quality Effect	Beneficial. The more efficiently the cow utilizes nitrogen and phosphorus in the feed, the less that ends up in the watershed.			Detrimental. Inefficient dairy feeding leads to lower milk production per unit feed and may increase nitrogen and phosphorus imports and losses to the watershed.
GREENHOUSE GASES				
Are animals fed in groups?	High producing cows, low producing cows, dry cows, transition cows, and multiple heifer groups are each fed separately or distinct rations as individuals.		Lactating, dry cows and heifer groups are each fed separately or distinct rations as individuals	No.
How often are feed rations balanced?	Rations are balanced monthly or more often as feed quality changes.	Rations are balanced at least 4 times a year or more often if forages change.		No regular ration balancing is done.
How often are forages tested for quality?	Forages are analyzed for nutrient content monthly or more often if forages change.	Forages are analyzed for nutrient content at least 4 times a year or more often if forages change.		Forages are not regularly analyzed.

How closely are the nutritionist's recommendations followed?	Very Closely.	Closely.	Somewhat Closely.	Do not interact with a nutritionist on a regular basis.
Are the Milk Urea Nitrogen (MUN) values within the normal range of 8-12?	Yes.			No.
Greenhouse Gas Mitigation Effect	Beneficial. Feed management often reduces nitrogen imports to farms, and improves nitrogen cycling between a farm's herd and crop fields. More efficient use of feed means less nitrogen and volatile solids available for production of N_2O and CH_4 in manure management (See Nitrogen Management and Manure Storage sections) as well as reduced enteric CH4. Additionally improved feed efficiency reduces the amount of feed per unit of milk – which reduces emissions from growing, harvesting, and transporting feed.			Detrimental. Excess nitrogen in the diet increases N in manure. Nitrogen not taken up by plants is lost to the ecosystem including increased N_2O emissions.
Overall GHG Rating	**Beneficial 1**	**2**	**3**	**Detrimental 4**
Adaptation to Climate Change	As agricultural land becomes more active to produce bioenergy to reduce fossil fuels and/or as crop yields are affected by extreme weather, more efficient use of feed will help farms manage risk. More intensive herd			Inefficient dairy feeding may reduce a farm's ability to cost-effectively produce enough feed in an environment with increased competition for land and year-to-year variability in crop quality and yield. Herds may be more susceptible to stress from extreme heat, cold,

	management may also help herds adapt to extreme weather patterns/climate change.			etc. from changing climate patterns.
Other Impacts	Well-managed diet may increase milk production per unit of feed, reduce costs, and increase profits. Air quality may improve due to lower particulate matter emissions.			Herd productivity and profitability may suffer. Increased nitrogen emissions can contribute to airborne particulates.

Summary Note: Precision dairy feed management often reduces nitrogen imports to farms, increases feed and land-use efficiency (milk production per unit of feed as well as per acre), decreases enteric methane production, and improves nitrogen cycling between a farm's herd and crop fields. More efficient use of nitrogen leads to less surplus nitrogen in the soil and reduced nitrous oxide emissions. Improved milk production per acre decreases production and supply chain GHG emissions (e.g., from fertilizers, tractors, transportation) associated with growing and transporting the grain and forage crops. If a farm uses anaerobic storage, precision dairy feed management also reduces the volatile solids that produce methane from stored manure, therefore reducing methane emissions.

AEM Tier 2 Worksheet: **Dairy Manure Storage** **Greenhouse Gas Mitigation Opportunities**	**Potential Opportunity**

General Note: Anaerobic (lacking oxygen) storage systems produce methane, more in the warm summer, less in cool and cold periods. The deep pit storage units commonly used in NYS are mainly anaerobic. While deep pit manure storage helps improve manure management from a water quality standpoint, it can increase greenhouse gas emissions as compared to daily spreading.

WATER				
Overall Water Rating Manure and Fertilizer Storage Tier 2	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Water Quality Effect	Beneficial when used to enhance management of manure and fertilizer nutrients in crop fields.			Detrimental. Runoff and/or leaching of manure and/or fertilizer nutrients poses higher risk to surface and/or ground water quality.
GREENHOUSE GASES				
Does your farm store manure? If yes, how many months of storage capacity exists? What type and number of animals contribute to the storage?				
How is most manure stored on your farm?	Storage of liquid manure under a cover with methane gas metered and consistently flared or combusted for generation of electricity/ heat or cleaned & compressed natural gas for multiple purpose.	Storage of solid manure under a roof or cover. OR Manure is applied to fields roughly on a daily basis.	Covered storage has a leaky cover, but flare (or electric generator) consistently combust methane.	Anaerobic storage of liquid manure in open air earthen pits or tanks. The meter and flare (or electric generator) with the covered storage does not work reliably.
Greenhouse Gas Mitigation Effect	Beneficial. Methane produced in the anaerobic storage is captured and combusted creating carbon dioxide and water vapor emissions.	Beneficial. Some methane losses from solid manure stored under a roof. Some indirect losses of nitrous oxide from daily applied manure.		Detrimental. Anaerobic storage of manure generates higher methane emissions and if not captured and combusted, increases GHG emissions.
Overall GHG Rating	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**

Adaptation to Climate Change	Covering storage units can reduce the amount of water from extreme precipitation events from causing overflow.			Uncovered storages are more susceptible to overflow from extreme rain events.
Other Impacts	Covered liquid storage can reduce odor problems. Reduces rainwater hauling. Reduces overflow events. Liquid storage increases flexibility in spring months when intensive field crop workload exists. Liquid storage conserves ammonia-N. Confined spaces and gases (H_2S, CO_2, CH_4, CO) demand more safety management. Can concentrate labor and equipment needs around intensive application periods, requiring efficient nutrient management plans and transfer and application systems.			Uncovered liquid storage can cause odor problems. Can collect rainwater that can overflow or increase hauling costs. Confined spaces and gases (H_2S, CO_2, CH_4, CO) demand more safety management. Can concentrate labor and equipment needs around intensive application periods, requiring efficient nutrient management plans and transfer and application systems. Liquid storage can require more landbase to meet CNMP due to conserving ammonia-N.

Summary Note: Some management practices, such as long-term liquid storage, are beneficial for water quality but detrimental to the atmosphere due to greenhouse gas emissions (for example increasing methane emissions). Because methane is a potent greenhouse gas, mechanisms to capture and flare methane are of the highest priority on dairy farms interested in GHG mitigation, and with such mechanisms, liquid manure storage does not have to increase methane emissions.

AEM Tier 2 Worksheet: **Manure and Fertilizer Nitrogen Management** **Greenhouse Gas Mitigation Opportunities**	**Potential Opportunity**

General Note: Improved crop nitrogen use efficiency reduces loss of nitrogen to surface and groundwater due to processes such as leaching and volatilization and also reduces nitrous oxide emissions. Additionally, significant fossil fuel inputs (and associated CO_2 emissions) are currently required to manufacture synthetic nitrogen fertilizers, so any reduction in synthetic N fertilizer rates represents fewer GHG emissions from their production.

WATER				
Overall Water Rating from Nutrient Management: Manure and Fertilizer Management Tier 2	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Water Quality Effect	Beneficial. Efficient nutrient recycling by crops is achieved through applications based on the right timing, source, rate, and method.			Detrimental. Unused N may enter ground and surface waters. Opportunities exist to improve manure and fertilizer use for both crop production and water quality.
GREENHOUSE GASES				
Do you keep records of nutrient applications to fields?	Records are kept for each field of the amount applied, source, timing, application method, crop yield, and rotation.		Records are kept only of the amount applied.	No records of amount N applied, crop yields, or rotations for each field.
How often do you test manure for nutrient content?	There is a history of manure testing that characterizes variability throughout the year. **AND** Manure is tested every year.		Manure is tested at least every other year.	Manure is rarely or never tested.
How is nitrogen application rate determined?	Account for past and current manure application rates, soil N supply potential, crop history, and yield records. **AND**		Some consideration of previous manure application rates, soil nitrogen supply	No accounting of previous manure application rates, soil nitrogen supply potential, crop history, or yield records.

	Routinely conduct field nitrogen management tests. **AND** Only enough N is applied to provide crop needs.		potential, crop history, or yield records.	
What is the timing of synthetic and manure N application?	Applied as close to the period of maximum crop nitrogen uptake as possible, often as a split application.			Fertilizer and/or manure is applied outside the growing season.
Greenhouse Gas Mitigation Effect	Beneficial. Efficient nitrogen use by crops leads to less direct and indirect N_2O emissions.			Detrimental. Surplus nitrogen not taken up by crops may be emitted from the soil as N_2O.
Overall GHG Rating	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Adaptation to Climate Change	High levels of nutrient management will help maintain and/or improve crop yield and quality during changing climate patterns as well as make the most of expensive cropland.			Inefficient nutrient management may further jeopardize crop yield and quality during adverse conditions brought on by climate change.
Other Impacts	Reduced synthetic fertilizer N use reduces both costs and GHG emissions from fertilizer manufacturing. Air quality may improve due to lower particulate matter emissions.			Synthetic N is both very costly and very energy intensive making it both a high GHG emitter and expensive for the farm. Increased nitrogen emissions can contribute to airborne particulates.

Summary Note: Improved timing of field application coupled with more accurate N rates result in increased crop nitrogen use efficiency, decreased potential for negative effects on water quality, and reduced GHG emissions. Potentially higher or sustained yields with lower fertilizer N inputs represent reduced costs and increased profits, along with reduced supply chain emissions from avoided fertilizer purchases.

AEM Tier 2 Worksheet: **Forest Management** **Greenhouse Gas Mitigation Opportunities**	**Potential Opportunity**

General Note: Twenty percent of farm land in New York is forested. Forests provide many benefits including improved water quality and climate change mitigation. Forests store carbon in trees and in soil and also in long-lived wood products after harvest. Forests can provide renewable fuel by means of bioenergy which if used efficiently can reduce fossil fuel use and GHG emissions. Forests also provide habitat for many species of plants and animals. Forests in riparian areas next to streams can remove excess nutrients and provide shade to maintain habitat and cool water temperatures needed by some fish species. Perennial cropland provides many of these same benefits including reduced erosion, increased soil carbon sequestration, and habitat.

WATER				
Overall Rating from Forest Management Tier 2	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Water Quality Effect	Healthy, well-managed forests and forest road systems help protect soil and water resources.			Loss of canopy to soften rainfall impact as well as poorly managed forest roads increase soil erosion and nutrient loss.
GREENHOUSE GASES				
Does the landowner have a forest management plan?	Forest management plan is prepared by a professional forester and is being followed. The plan is less than 10 years old.	No forest management plan. OR Plan is not being followed.	Not using best management practices for harvest.	Conversion of forestland to development or cropland.
Greenhouse Gas Mitigation Effect	Managing a forest sustainably for long-lived timber products or bioenergy will increase the carbon sequestration per acre.	An unmanaged forest does not have maximal growth potential, reducing its ability to sequester carbon.	Detrimental. Poor management can increase erosion and decrease water quality. Poor management can also reduce growth rates and increase undesirable species.	Detrimental. Significant loss of soil carbon. Loss of timber product carbon sequestration potential.
Overall GHG Rating	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**

Adaptation to Climate Change	Healthy forests are less susceptible to damage from diseases, pests and climate change.			
Other Impacts	Improved long-term profits, greater forest health, greater animal and plant species diversity.	Animal and plant habitat maintained.	Short term profits, but sustained income from forest may be in jeopardy.	Loss of forest habitat. If converted to residential or commercial development, issues with stormwater management, neighbor relations, and availability of cropland may arise.

Summary Note: Well-managed forests can reduce GHG emissions, improve water quality, and provide short and long-term financial benefit from sustainable harvesting.

AEM Tier 2 Worksheet: **Soil Management** **Greenhouse Gas Mitigation Opportunities**	**Potential Opportunity**

General Note: It takes decades to build up (sequester) soil carbon, but only months or a few years to lose it due to tillage and other practices. Soil carbon (closely related to soil organic matter) is beneficial for soil health for many reasons, including improved water infiltration, improved water retention, reduced erosion, improved tilth, improved biological activity, and improved nutrient cycling. Increasing the amount of carbon stored in soils has multiple benefits, including reducing carbon dioxide in the atmosphere.

WATER				
Overall Rating from Soil Management Tier 2	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Water Quality Effect	Adequate soil organic carbon is important for soil health (the capacity of a soil to function) which has a direct impact on crop production and an indirect impact on water quality. Healthy soils are able to absorb and supply water, retain nutrients, suppress pests and weeds, and produce high crop yields.			Unhealthy soils with less soil carbon are more likely to erode, have a higher potential for runoff during storm events, and make crops more vulnerable during droughts. Soil erosion can carry sediments, nutrients and pesticides to surface water bodies degrading water quality.
GREENHOUSE GASES				
Roughly what portion of your land is in each of these categories	Conversion of annual cropland to perennial cropland or forestland _________%	Conservation Tillage _________%	Conventional Tillage _________%	Conversion of perennial cropland or forestland to annual cropland _________%
Greenhouse Gas Mitigation Effect	Beneficial. Perennial crops, pasture, and forest root systems sequester soil carbon and use nutrients more efficiently, reducing GHG emissions.	Over many years, carbon can be sequestered in soil but this process can be quickly reversed if tillage is later increased making it difficult to qualify as 'permanent' mitigation of GHG.	Conventional tillage reduces soil organic carbon and increases CO_2 emissions.	Detrimental. Conversion of forest to cropland results in large release of carbon, relatively quickly.

Overall GHG Rating	**Beneficial 1**	**2**	**3**	**Detrimental 4**
Adaptation to Climate Change	Compared to annual crops, the root systems of perennial crops can greatly reduce erosion from extreme rain events.	Healthy soils are more able to absorb and store water in both dry and wet climatic conditions.		Additional acres for annual crops may help manage risk for the livestock herd and farm business. However, annual crops may be more vulnerable to extreme weather events than perennials.
Other Impacts	If maintained as forest, a great deal of carbon is sequestered in trees and in soil.	Improving soil health improves crop yield.		Loss of forest means loss of forest plants and animals as well as reduced ability to remove nutrients from groundwater and surface water. Loss of forests next to streams also increases stream water temperatures which reduces habitat quality.

Summary Note: There is significant opportunity to store carbon in soil for long periods of time, especially with perennial vegetation such as forests and permanent hay or pastureland. However, soil carbon can be lost quickly with tillage, and GHG mitigation benefits are quickly lost if a long term sod is plowed. Increased soil carbon also increases soil health, benefiting crop productivity and water quality. The highest potential for carbon sequestration on agricultural land comes from active management of recently abandoned pastures and fields toward afforestation with optimal woody plant compositions. Although not impossible, changing the make-up of woody plant species on unmanaged fallows or abandoned fields will be much more expensive than active management at the outset.

AEM Tier 2 Worksheet: **Energy Conservation and Efficiency** **Greenhouse Gas Mitigation Opportunities**				**Potential Opportunity**

General Note: Nearly all farms use fossil fuels. When fossil fuels are mined and combusted, carbon is moved from very long-term geologic storage into the atmosphere as CO_2 increasing the amount of greenhouse gases in the atmosphere. Eighty percent of human-induced greenhouse gases come from combustion of fossil fuels, so increased energy efficiency can reduce these emissions.

WATER				
Water Quality Effect	There is no Tier II worksheet for energy efficiency impacts on water. However, reduced energy use indirectly impacts water as water is often used for energy generation (hydroelectric dams) and processing (use of river water for industrial cooling, or in mining).			
GREENHOUSE GASES				
Have you had an energy audit to find ways to improve efficiency and reduce use?	Yes, and we have implemented all recommended changes.	Yes, and we have begun to implement changes that are most cost effective.	Yes, but we have not implemented any changes.	No.
Do you track your energy use?	Yes and we look for ways to reduce our consumption.	Yes, but only to track monthly fluctuations in energy use.		No.
Overall GHG Rating	**Beneficial** **1**	**2**	**3**	**Detrimental** **4**
Adaptation to Climate Change	Farms may need to increase energy use for irrigation, barn cooling, etc. to adapt to changing climate patterns. Energy efficient systems will help control costs.			Potentially higher energy costs could limit a farm's ability to invest in irrigation, barn cooling, and other systems necessary to remain profitable under changing climate patterns.
Other Impacts	Improved energy efficiency often reduces costs and increases profits. Energy efficiency can also improve air quality by reducing emission of pollutants. Energy conservation and improved efficiency reduce GHG emissions to the atmosphere and help mitigate climate change.			Generally more costly. Fossil fuels combusted for energy account for 80% of the global GHG emissions.

Summary Note: Bioenergy can reduce GHG emissions, but does not always do so. Inefficient bioenergy systems such as low-efficiency outdoor wood boilers can reduce air quality and increase GHG emissions. In general, improved energy conservation and energy efficiency provide the greatest opportunities to reduce fossil-fuel based GHG emissions, while reducing costs and saving labor.

SUMMARY:

Working to improve one natural resource may benefit or have detrimental effects on others. Taking stock of how existing and future management affect **soil, water, air, plants, animals, energy, greenhouse gases, people, and economics** can result in more effective plans and additional benefits to farms and communities both now and into the future.

Additional Comments:

As mitigation of greenhouse gases is of value to society at large, there is often interest in quantifying both the GHG emissions from a process and the GHG mitigated by a process. This way, different processes within a sector (a natural gas and a coal electric generating plant can be compared) or across different sectors (emissions from the energy sector can be compared to emissions from transportation or agricultural sectors) can be evaluated for opportunities for mitigation. For example, under the Regional Greenhouse Gas Initiative (RGGI), only the electric sector is regulated for emissions, but they can purchase offsets to achieve their mitigation goals. Offsets are GHG emission reductions achieved by non-regulated parties (e.g., farms). EPA Climate Leaders define credible offsets to have all of the following qualities.

1. REAL: The quantified GHG emission reduction must represent actual emission reductions that have already occurred.
2. ADDITIONAL: The project-based GHG emission reductions must be beyond what would have happened anyway or in a business-as-usual scenario.
3. PERMANENT: The GHG emission reductions must be permanent and must be backed by guarantees in the event that they are reversed (e.g., re-emitted into the atmosphere).
4. VERIFIABLE: The GHG emission reductions must result from projects whose performance can be readily and accurately quantified, monitored, and verified.

For instance, a manure storage with a cover and flare is a good example of a credible mitigation system.

1. REAL: Methane captured and destroyed with a manure storage cover and flare is real, because a meter can measure the amount of methane captured and destroyed. It will not measure the methane that it does not capture, but it will measure the volume of methane that is actually captured and destroyed at the flare.
2. ADDITIONAL: Farms are installing storage to protect water quality. While there are other benefits to covering a manure storage (reducing odors, reduces manure hauling, etc.), there is no ‘reason’ to cover and flare a storage given the cost of the cover and the relative minor benefits of covering. Thus, it is an additional project.
3. PERMANENT: The carbon in CH_4 that is flared to CO_2 is permanent. Once CH_4 has been oxidized to CO_2, it is 34 times less potent a GHG than CH_4.
4. VERIFIABLE: Manure covers with flare are equipped with meters both for measuring the amount of methane produced and the amount flared. That which is not captured and flared will not show up in the meter and therefore will not count as mitigation.

In the matrix below, the topics included in this worksheet are compared for meeting the standard for obtaining credit as a GHG offset. This ranking is not intended to favor one practice over another. One may choose to do a practice for many reasons other than obtaining credits for a GHG offset. For example, many of these practices will reduce GHG emissions, but they may also be cost-effective. Such practices would be recommended both to improve profits and to reduce GHG emissions, but because they have financial benefits they may not qualify as "additional", and thus may not qualify as GHG offsets.

PRACTICE	REAL	ADDITIONAL	PERMANENT	VERIFIABLE	Comment
Dairy Feed Management	It is highly likely that the benefits are real.	NO. Because feed efficiency is financially beneficial, it is not considered additional.	Likely the benefits are permanent.	It is very difficult to directly measure the benefits, so models must be used, which introduces substantial uncertainty.	
Manure Storage Cover with Flare	YES	YES	YES	YES	
Manure and Fertilizer Nitrogen Management	Reduced N fertilizer use has real benefits.	Probably not. Reducing N fertilizer use is likely to be financially beneficial so may not be additional.	Likely the benefits are permanent.	At this time, it is probably very difficult or expensive to prove the mitigation is verifiable.	
Forest Management	YES	Perhaps not. Good forest management generates high quality wood products which are financially beneficial so may not be additional.			
Afforestation	Perhaps not. For example, converting crop land to forested land does not mean real benefits occur if it requires the equivalent acres of forestland to become deforested in a	YES	YES	YES	

PRACTICE	REAL	ADDITIONAL	PERMANENT	VERIFIABLE	Comment
	different location to produce the crop.				
Soil Carbon Sequestration in Forestland	Likely the benefits are real.	Not likely because existing forest is already sequestering carbon.	If kept in conservation easement as a forest, then yes.	YES.	
Soil Carbon Sequestration in Cropland	Likely the benefits are real.	Perhaps yes, though increases in soil fertility and resulting crop productivity may provide financial benefits so it is not entirely additional.	NO. It takes many more years to build up soil carbon than it takes to lose it.	At this time, it is probably very difficult or expensive to prove the mitigation is verifiable.	
Energy Efficiency	YES	Perhaps not. There would likely be financial benefits so it is not entirely additional.	YES	YES	

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