GLS- Sustainable Agricultural Practices

W0-W.O.R.M.S.: An Introduction

Working On Restoring and Making Soil

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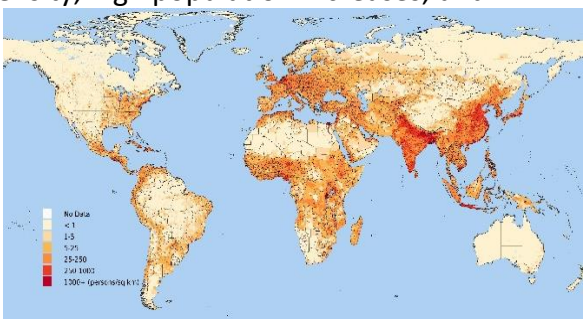
Life-long learning for resilience and sustainability.

This paper uses material originally posted to the Rural Training Center-Thailand (RTC-TH) on Jan 19, 2010 (Rev. 2018) based on work conducted in Thailand, from 1999-2014. This is a major revision/update of the original papers. W.O.R.M.S. grew from a single program to be the overall soil management effort of GLS Sustainable Agricultural Practices.

Introduction: The 2015 UN Food and Agriculture Organization (FAO) Status of the World's Soil Resources, says "*the majority of the world's soil resources are in only fair, poor or very poor condition. Today, 33 percent of the land is moderate to highly degraded due to the erosion, salinization, compaction, acidification, and chemical pollution of soils.*" The FAO soil erosion map shows areas where decades of decline are reversed (blue). Orange and red show serious soil degradation. They match with areas of high population density, high population increases, and differences in the economy, and technical development. More soil management training is needed globally. W.O.R.M.S. is a low-cost way to effectively teach people what they can do about the global soil issues (which are summarized in the table on the right).

Global Soil Erosion



World Population projected to 2025

Summary of Major Global Soil Issues

The driving forces behind soil issues are human activities that disrupt natural processes. The human disruptions have increased more rapidly since the Industrial Age leading to biodiversity loss impacting soils. (Listed in no particular order.)

Issue	Factors	Soil Issue	Causes/Impacts
Soil erosion	Loss of vegetation, biodiversity loss, and soil moisture; paves the way for erosion.	Waterlogging	Poor drainage; flooding; sea level rise;
		Deforestation	Land clearing, mining, construction, insect infestation, wildfires, biodiversity loss.
Excessive use of Agri-chemicals	Contaminates soil, crops, livestock, people, and water; destroys soil organisms weakens soil, and paves the way to erosion.	Salinization	This is a by-product of irrigating in arid lands where evaporation exceeds precipitation; wind erosion from salinized areas to non-salinized areas.
Overgrazing	Loss of range land increases animals/unit of land; climate change causes a shift to previously ungrazed land.	Desertification	Loss of vegetation, low soil organics, salinization, soil erosion, overgrazing; climate change (more frequent and longer droughts).
Nutrient depletion	Push to increase crop yields, monoculture planting	Landslides	Deforestation, hydro projects, mining, wildfires, earthquakes.

They can be empowered to take immediate action with limited resources at the local level. At the same time, they can use W.O.R.M.S. to 1) Improve local education; 2) protect local ecosystems and biodiversity; 3) protect, grow, and maintain soils; 4) build a stronger sense of community, and 5) increase community resilience and sustainability. All of these contribute to food production and food security.

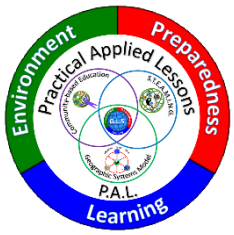
W.O.R.M.S. is a holistic program integrating education, environmental awareness, and emergency preparedness. It uses Community-based Education to make practical applied lessons to meet local needs as defined by the community. W.O.R.M.S. systematically integrates four existing, time-tested programs: G.R.O.W. (Getting Real On-Farm Weather), S.O.S. (Save Our Soil), S.O.W. (Save Our Water), and C.O.M.P.O.S.T. (Creating Our Most Precious Organic Soil Treatment).

The W.O.R.M.S. logo shows the four components.

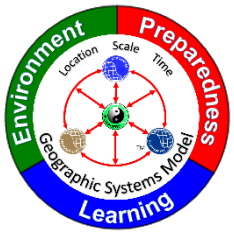
GLS Community-based Education (C-bE) is an informal people-to-people teaching method. We focus on three main topics: Education, the environment, and preparedness. C-bE can be used in the classroom or remote, rural areas with no schools. It is "Education of, for, and by the people." This means the ideas for lessons, or the curriculum originates at the grassroots level (the community). It is NOT a top-down bureaucratic program. Our relationship with communities is based on seven key principles: Common sense, Content, Commitment, Cooperation, Communication, Consistency, and Continuity. This is done based on mutual respect, mutual benefit, inclusion, and diversity using Nature as the guide. The inherent strength of a community lies in the diversity of the people, just as an ecosystem persists and is resilient due to biodiversity. [**Note:** Since COVID, we use the internet connectivity for much of this work. This helps reduce costs, but we are open to discussions on how to accommodate communities with or without internet access.]

GLS Community-based Education

All W.O.R.M.S. lessons are created using the GLS Community-based Education (C-bE) model to make and use Practical Applied Lessons (P.A.L.) adapted to local community needs and interests. GLS C-bE methods and lessons are adaptable for all ages from K-12 to college/adult. The goals are to get people to be life-long learners and build community sustainability and resilience.



Practical Applied Lessons (P.A.L.) are the deliverable to a community. Learning is most useful for a person when the lessons are relevant to their daily life. This is why the local community and learners must be part of the lesson creation process. Inclusion of local and Indigenous knowledge is critical as the world is perceived differently through the eyes of communities and individuals. The world is dominated by "Western" science, but that is not the only science in the world. Holistic inclusion is at the heart of GLS Cb-E and the P.A.L. process. The lessons must produce good results for the residents. It is their community. We are only here to share our knowledge, skills, and experience to empower them to be more resilient and sustain their community.

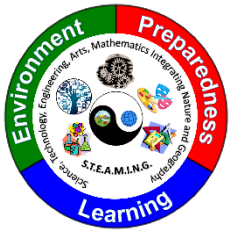


P.A.L. uses the Geographic Systems Model (G.S.M.) to connect all life, physical, and social sciences. This is a conceptual model of the world using the four environmental spheres: Atmosphere (air), Lithosphere (land), Hydrosphere (water), and Biosphere (living organisms). The red arrows connect knowledge across discipline, geographic, and cultural boundaries. They also indicate processes that move matter and energy between the environmental spheres. These movements can be direct or indirect, fast or slow, and can be actions (inputs or outputs) or feedback. It lets people systematically compare and contrast places on Earth using the concepts of Location, Scale (level of detail), and Time. The model is flexible and can incorporate local and

Indigenous knowledge. No matter where people live on Earth, they can all relate to the environmental spheres. Culture is defined as the way people interact with the environment and with other people. The basic interactions with the environment are breathing, drinking, eating, and finding shelter. All of these human actions impact the environment. Sustainability is the ability of people to interact with their environment so that future generations can continue to exist on Earth. Resilience is the ability of people to continue to exist when confronted with disruptions in their lives (especially those events that impact their abilities to breathe, drink, eat, and find shelter).

The table on the right shows the connection between each W.O.R.M.S. program to the Geographic Systems Model. The knowledge is shared, and users can apply it in their local situation to determine if it meets their needs. It is not about being right or wrong. It is about being open to considering other perspectives and ideas to solve problems.

W.O.R.M.S.		Geographic Systems Model	
G.R.O.W. Getting Real On-Farm Weather			**Atmosphere (Air)** Rain = Amount, wind, storms Sunlight = Heat, amount, angle
S.O.S. Save Our Soil			**Lithosphere (Land)** Soil = Type, quality Slope = Angle, aspect, length Erosion = Condition, amount
S.O.W. Save Our Water			**Hydrosphere (Water)** Water Surface sources Subsurface sources
C.O.M.P.O.S.T. Creating Our Most Precious Organic Soil Treatment			**Biosphere (Living Organisms** Flora = Natural vegetation, crops Fauna = Livestock, wildlife People = Customs, economy



S.T.E.A.M.I.N.G. is the GLS C-bE enhancement of the Science, Technology, Engineering, Arts, and Mathematics (S.T.E.M./S.T.E.A.M.) education methods by Integrating Nature and Geography. There is a growing awareness that people need to "think outside the box" to solve today's complex problems. GLS C-bE advocates teaching outdoors in Nature. This gets students outside the box of the classroom and into their local community where Nature and the community are the learning center and library. Lessons are community-service projects. Students are engaged in building a sense of community while improving community sustainability, resilience, and preparedness. One of the best ways to learn is to try to teach and share knowledge. The project team helps students learn to communicate and work together. The service project is a practical exam that replaces written paper exams. We don't compete with schools, nor do we try to reform them.

We begin our introduction to the W.O.R.M.S. components with Getting Real On-Farm Weather (G.R.O.W.). Weather affects all the other components. It is the source of light and heat energy in life and agriculture. It is important in making soil. It provides air, water, and organics enabling the soil to support life.

W.O.R.M.S.-G.R.O.W. Most farmers get their weather reports from the radio or TV. The weather reports are often from stations far from the farm. Weather can vary over short distances. It can be raining in town but not at the farm. It is better to have weather data on the farm. G.R.O.W. includes instructions for making the equipment needed (much of it off-the-shelf). You only need to buy a thermometer and a liquid measuring cylinder.

W0-W.O.R.M.S.: An Introduction

Working on Restoring and Making Soil

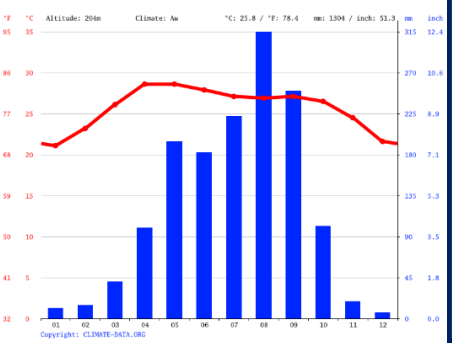
Thai village elementary school students practice measuring rainfall from their homemade rain gauge. Weather records from the family farm can help to monitor the farm's soil and water resources, such as:

1) **Study soil erosion** (e.g., rainfall and wind direction). [**Note**: The critical weather data for soil erosion are rainfall, and storm direction.]
2) **Study water resources** (e.g., rainfall, temperature, wind speed, and direction).
3) **Know the weather impacts** on livestock, workers, plant growth, drying times, etc. (e.g., temperature humidity, wind speed, direction, etc.).

G.R.O.W. Measurements		
Temperature	Dry bulb	Measurement
	Wet bulb	Measurement
	Windchill	Measure, calculate, & use reference tables
	Heat Stress	
Moisture	Relative Humidity	
	Dew Point	
	Precipitation	Measurement
Wind	Speed	Estimated by observation
	Direction	Measurement
Clouds	Identification	Observed Reference chart
	% Sky Cover	
	Height	Calculated

The table on the right shows the data collected, processed, and displayed by manual calculations, handheld calculators, or computers (if available). All this work correlates to academic classroom lessons. G.R.O.W. is designed around practical applied lessons to connect academics to daily life on the farm.

The goal of G.R.O.W. is for farmers to have relevant weather data for their farms summarized like the table below (right). What is missing from this summary are: wind speed and direction, and solar information (daylight hours, solar angles, evapotranspiration, etc.).



From North Thailand Climate Data During 54 years (1951 - 2004)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Tropical Cyclones	-	-	-	-	5	2	9	17	23	15	1	-	72
Thawangpha Rainfall (mm)	11.0	12.6	29.2	108.0	206.2	202.4	244.1	302.3	175.6	80.4	22.7	5.9	1400.04
Seasons	Winter		Summer		Rainy (SW Monsoon)						Winter (NE Monsoon)		
Ave Temp	23.1°C		28.0°C		27.3°C						23.1°C		
Temp Range	17.1-30.8°C		21.4-35.8°C		23.7-32.2°C						17.1-30.8°C		
Ext Temp	0.8°C		44.5°C								0.8°C		
Rainfall (mm)	105.5		182.5		952.1						105.5		

The graph on the left is a typical climate summary. G.R.O.W. lessons follow the Geographic Systems Model concepts of Location, Scale, and Time to present G.R.O.W. data to highlight seasonal weather patterns for farm operations.

W.O.R.M.S.-S.O.S. (Save Our Soil): Soil is not dirt. Soil supports life. Soil is the heart, soul, and essential spirit of the land. We've listed the S.O.S. testing methods in the table below. These are no-cost/low-cost, no-tech/low-tech. They are suitable for remote rural family farms. Most of the equipment can be homemade using off-the-shelf parts and recycled materials. The results cannot match those of a full soil laboratory. But most rural farmers cannot afford the lab fees. Our 15 years of use in rural northern Thailand proved the efficacy of these tests. These lessons can be readily taught in most schools as practical

Identifying and classifying a soil using a simple soil test method, observation, measurement, and a reference chart.

math and science lessons used in daily life rather than abstract textbook lessons. The table on the right shows the basic soil testing methods used in W.O.R.M.S.-S.O.S.

The tools needed for studying soils are commonly found on most family farms. It isn't necessary to have all the items shown. Before doing any of the tests, prepare well by reading the procedures to make sure you have the minimum tools to do the job. [**Note**: We tend to use plastic bottles for fieldwork to avoid the possibility of broken glass.]

Farmers should conduct soil tests on their farms before starting any other soil management work. The first soil studies form the baseline record. This creates a reference point to assess the progress of all subsequent soil management activities.

The simple soil test methods in W.O.R.M.S.-S.O.S. use direct observations (subjective) and well as objective relative measurements. The relative measurements allow for seeing changes over time to monitor soil quality (e.g., improving, or declining).

Trait	Test Methodology		Notes
Color	Visual	Observation	Surface; Profile needs digging.
Texture	Visual	Direct measurement	Shallow digging <15-25 cm
		By touch	
	Sedimentation Bottle & Texture Triangle		
Structure	Surface Tests	Push Rod	
		Garden Fork	
		Crumb Test	
	Subsurface Tests	Crumb Test	Dig hole 30 cm x 30 cm x 30 cm; do Earthworm census, too.
		Percolation	
Chemistry	Soil Moisture	Appearance & Touch	
	Earthworm Census	Direct measurement	
	Soil pH	Direct measurement	Shallow

A	Garden Fork	J	Ruler
B	Push Rod	K	Phone
C	Shovel	L	Straight sided bottle
D	Tape measure	M	Tarp
E	Trowel	N	4-L bottle of water
F	Bucket	O	White vinegar
G	Magnifying Glass	P	Baking soda
H	Stopwatch	Q	Measuring cup
I	Two empty water bottles		

Another training topic is slope measurement of three variables: slope angle, slope length, and slope aspect. All of these can be measured using handmade tools with commonly available items on the farm or recycled materials from the trash. If you don't have a magnetic compass, you can rely on your local knowledge. You only need to know the cardinal directions of North, South, East, and West for your area. [**Note:** There are five parts to W.O.R.M.S.-S.O.W. 1, 2, 3, 4, 5.]

S.O.W. (Save Our Water): Climate change is real. Water resources need to be carefully managed. You may need more water for your farm. You need to keep more of what you have. We started S.O.W. as a conservation effort. We trained people to be aware of their daily water use.

Many countries face water shortages

S.O.W. training begins with the shape of the land. We use the same tools used for S.O.S. Farmers need to learn how water flows over their farm. They use this knowledge to slow it down and let it soak in. They need to minimize evapotranspiration water losses and learn to follow Nature's use of water.

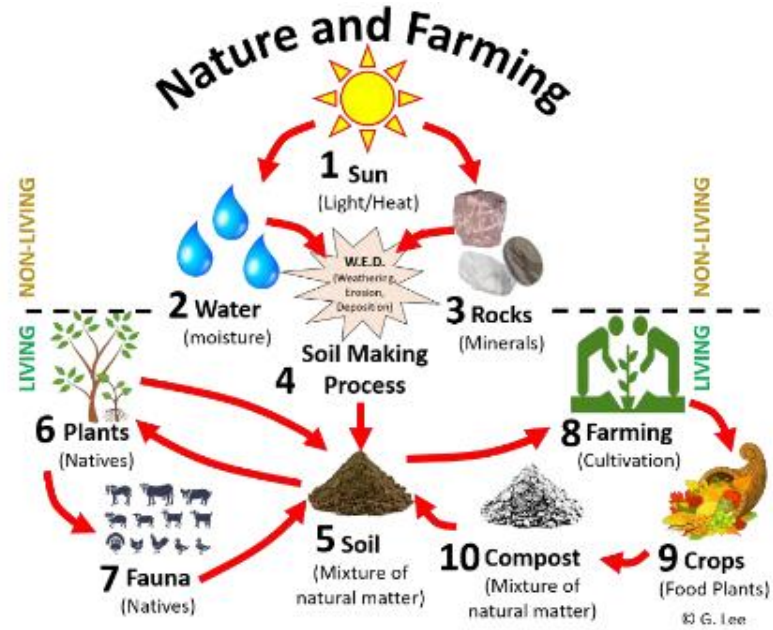
We taught no-cost/low-cost, no-tech/low-tech ways to store water. On farms, ponds are often used. But with climate change, ponds will lose more water through evaporation. Building water tanks are expensive.

Catching rainwater from a lean-to roof

Soil moisture is a no-cost water storage method that helps produce crops and support livestock. S.O.W. teaches farmers to work with Nature to hold water on their farms. Having healthy soil is a good start. Most farmers lack the weather data to know how cost-effective rainwater harvesting will be on their farms. We urge them to set up a G.R.O.W. weather station.

W.O.R.M.S.-C.O.M.P.O.S.T. (Creating Our Most Precious Organic Soil Treatment): Making compost should be a top priority for sustaining small family farms. First and foremost, it is an outstanding soil amendment to restore and maintain overall soil health. It improves soil structure and increases soil resistance to erosion. It also increases soil moisture retention. Improving soil health leads to healthier plants. Farmers can reduce the purchase and use of expensive agricultural chemicals (a contributing soil erosion factor). [**Note:** There are three parts to W.O.R.M.S.-C.O.M.P.O.S.T. 1, 2, 3.]

Thai elementary students learning to make compost



Making compost imitates Nature. The diagram on the left shows the basic recipe Nature uses to make soil. It takes time to make it. The speed depends on the type of rocks, and the available amounts of heat and moisture. The Geographic Systems Model and G.R.O.W. have lessons about the soil-making process. Other factors affecting the soils on your farm are the local ecosystems (related to climate) and the history of land use.

There are many factors beyond a farmer's control. W.O.R.M.S. lessons are about making effective decisions about the few things a farmer can control on the farm.

The table on the right shows the different composting methods available in W.O.R.M.S.-C.O.M.P.O.S.T. training. No special tools are needed. Each has advantages and disadvantages and requires different amounts of time and energy to prepare and do. There are methods suitable for young children and the elderly.

Composting Methods
Hot Composting
Cold Composting
Bag Composting
Container Composting
Square-foot Composting
Trench Composting
Sheet Composting
Worm Composting
Composting Toilet

Composting reduces trash, air pollution, and the amount of material going into the trash dumps. We urge people to make composting a habit. If your neighbors won't do it, offer to take their compostable wastes. Gather it from the elderly who cannot work. In exchange, "pay" them with some of your fresh produce. Get children to help out. All this helps build a stronger sense of community. The soil benefits of composting are vital to making healthy soil. Most of the ingredients you can get free from others. As for your wastes, well, you paid for some of them. So why not get full value for your money?

W.O.R.M.S. Tool Use Matrix				
Thermometer	✓	✓	✓	✓
Rain gauge	✓	✓	✓	✓
Flags	✓		✓	
Graduated cylinder	✓			
Stick level		✓	✓	
Measuring tape	✓	✓	✓	✓
Shovel		✓	✓	✓
Bucket		✓	✓	✓
Trowel		✓	✓	✓
Empty bottle		✓	✓	✓
Tarp		✓	✓	✓

Multiple Tool Use. The table on the right shows many of the tools used for W.O.R.M.S. One "standard" we have for our lessons and training is the principle of "no-cost/low-cost, no-tech/low-tech." Just as our programs are highly integrated, we try to keep things simple by having multiple uses for our tools and equipment.

Conclusion: W.O.R.M.S. uses no-cost/low-cost, no-tech/low-tech tools and methods. This is compatible for use in small rural family farms. These can be taught in schools (elementary to college/adult) using the GLS Community-based Education method. This makes classroom lessons relevant to students' daily lives, their families, and communities. Taking this approach helps raise awareness about soil management. It teaches basic skills to help restore degraded soils. It builds and maintains healthy soils. Healthy soils mean healthy plants. This supports biodiversity.

Summary

W.O.R.M.S is easy to do. Individuals can do this at home. We suggest starting in a small garden before using it on the farm. Taking smaller steps at the start with something new helps to build confidence with small successes.

Those wanting to use it in an existing school will find there is no change needed in the curriculum or school budget. We suggest schools try using W.O.R.M.S. in a school garden to grow food for the school cafeteria. This way the students, staff, and faculty all learn, see, feel, and taste the results of their efforts. The school garden can be a community demonstration garden to help spread the learning from students to families and the community.

To See The W.OR.M.S. Papers			
Getting Real On-Farm Weather	Save Our Soil	Save Our Water	Making Our Most Precious Organic Soil Treatment
G.R.OW.	S.O.S. 1, 2, 3, 4, 5	S.O.W.	C.O.M.P.O.S.T. 1, 2, 3