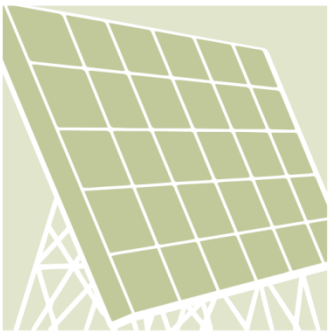
POWERING AGRICULTURE:

AN ENERGY GRAND CHALLENGE FOR DEVELOPMENT

TOOLBOX ON SOLAR POWERED IRRIGATION SYSTEMS (SPIS)



Module 2: Promote and Initiate

Food and Agriculture Organization of the United Nations

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Responsible
GIZ Project Sustainable Energy for Food – Powering Agriculture

Contact
Powering.Agriculture@giz.de

Download
https://energypedia.info/wiki/Toolbox_on_SPIS

About
Powering Agriculture: An Energy Grand Challenge for Development: https://poweringag.org

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ABBREVIATIONS

Ah	Ampere hour
CWR	Crop Water Requirement
DC/AC	Direct Current / Alternating Current
ET	Evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
Gd	Daily Global Irradiation
GIZ	Gesellschaft für Internationale Zusammenarbeit
GIWR	Gross Irrigation Water Requirement
GPFI	Global Partnership for Financial Inclusion
HERA	GIZ Program Poverty-oriented Basic Energy Services
H_T	Total Head
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IRR	Internal Rate of Return
IWR	Irrigation Water Requirement
MPPT	Maximum Power Point Tracking
NGO	Non-Governmental Organization
NIWR	Net Irrigation Water Requirement
NPV	Net Present Value
m^2	square meter
PV	photovoltaic
PVP	Photovoltaic Pump
SAT	Side Acceptance Test
SPIS	Solar Powered Irrigation System
STC	Standard Test Conditions
TC	Temperature Coefficient
UV	Ultraviolet
Vd	Daily crop water requirement
W	Watt
Wp	Watt peak

PROMOTE AND INITIATE

MODULE AIM & ORIENTATION

The promotion of modern and efficient Solar Powered Irrigation Systems (SPIS) requires a proactive promotion effort by development practitioners, solar irrigation suppliers and agricultural extension service providers due to insufficient awareness among the target group. This module guides through the most important process steps that have to be considered when disseminating or scaling-up Solar Powered Irrigation Systems.

Promotion activities are the most visible part of any promotion campaign. No such campaign can be conceived, however, without a thorough preceding analysis of objectives, target group and stakeholders and the related potentials and opportunities, risks and restrictions. In addition, no campaign can be approached without considering a systematic follow-up from the beginning onwards.

The **PROMOTE & INITIATE** module follows after the **GET INFORMED** module, where the individual components of an SPIS, as well as common system configurations are described. The next module is **SAFEGUARD WATER**, which is also relevant for any promotion of SPIS because it focuses on water governance issues and potential negative impacts of groundwater depletion through solar pumping. One important process step in the promotion of SPIS is access to finance. This is elaborated further in the **FINANCE** module that provides information and tools for financial service providers already financing or planning to finance SPIS. The last three modules on the **DESIGN**, **SET UP** and **MAINTAIN** of SPIS are important to determine what SPIS configuration can and should be promoted. The modules give an insight into the financial viability, technical feasibility and sustainability in investments in SPIS in a particular setting.

PROCESS STEPS

The module starts with an insight into three important processes that need to be carried out for the promotion of any technology. To begin, it is important to understand the pros and cons of SPIS in the target area. It does not pre-empt the detailed analysis of the viability of the technology in a given specific farm context, which is the aim of the following modules of the toolbox.

Once objectives and the target group of promotion interventions have been clearly outlined, promotion material has to be produced. The implementation of the promotion activities then have to be planned.

The initiation of actual projects or investments that have been motivated by the promotion campaign is again a process that requires pro-activity of the development practitioner and the agricultural advisor. In the last process steps of the **PROMOTE & INITIATE** module, information is provided on how to pursue this task.

1. ANALYZE OPPORTUNITIES AND RISKS

Promotion efforts provide specific information to targeted producers. This enables decision-making in view of securing and/or increasing the agricultural production potential by modernizing and improving irrigation capacities. It is therefore important to carry out a preliminary reflection of the possible benefits of a particular technology option, the prospect of its application in the specific rural context and the chances resulting there from.

The **GET INFORMED** module familiarizes the agricultural advisor or the development practitioner (the promoter) with the main aspects of the technology. Next, the promoter should obtain information on particular products and system solutions offered on the local market.

The tool **PROMOTE – SPIS Rapid Assessment** helps to understand the market for SPIS in a country and/or project region. The tool provides a report template guiding the author through the relevant aspects of SPIS that need to be assessed. This includes:

- a country/project specific assessment of irrigated agriculture, solar energy and agricultural finance;
- existing technologies, financing and promotion mechanisms; and
- a Strength Weakness Opportunity and Threat (SWOT) analysis.

Important: Not all technology solutions and the related services are available everywhere, local markets may be limited in the range of technology options offered.

Even within the same country, substantial regional differences may be found!

With a good information basis on the availability and specifics of technology options, the promoter can analyze the potentials of different solutions or approaches and reflect on opportunities resulting therefrom. This process step provides guidance on WHAT to ask WHOM.

It is essential to collect information on the following aspects:

- **Availability**:
  - Which technology options and support services are available / accessible in the specific promotion area?
- **Suitability**:
  - Is the environment supportive of large scale promotion of SPIS?
  - Does the catchment area provide enough surface and groundwater for short- and long-term irrigation development (see **SAFEGUARD WATER**)?
  - Other important preconditions are suitable soil and climate (e.g. solar irradiance) conditions, access to input / output markets, and infrastructure security.
- **Acceptability**:
  - What is the level of acceptance of different stakeholders for SPIS technology?
  - Is the cost benefit of SPIS in an area better than for alternative technologies?
  - What are acceptable ways to disseminate and promote information on SPIS in the target area?
- **Supportability**:
  - Are there existing or planned support programs in the target area for SPIS or its components, and are they accessible to producers? An

important aspect is the availability of subsidies for particular irrigation purposes. Subsidies may exist for PV-based modernization options, but also for diesel or grid-based electricity, which may have a significant impact on the financial viability.

- What service providers are accessible to producers?

However, it is also very important to provide unbiased information about possible restrictions and risks of SPIS.

- **Restrictions** are determined by technical (availability of technical solutions and services), environmental (availability of water, solar resource, suitability for specific crops) and economic (access to finances, positive return on investment and market prices, diesel prices, subsidies) factors. Any irrigation system should be designed taking these restrictions into account in order to ensure that an optimum range of operation is achieved.

- **Risks** mainly arise due to a deviation from the designed operational range and from operation principles. This may result in negative impacts on the environment (excessive water abstraction, over-irrigation) and on the cost-benefit ratio of the production (lack of water causes yield decreases, etc.).

Important: Not every irrigation technology is suitable for all crops and production approaches. Besides technical and agronomic restrictions, the cost-benefit ratio is a vital aspect to consider! In addition, it is important to note that changing an agricultural practice is more than merely an agronomic issue, but has social, gender, economic and environmental repercussions that must be assessed locally.

The analysis of restrictions and risks includes technical, environmental and economic aspects associated with the application of the technology options:

- environmental risks originate from the possibility of over-exploitation of water resources (see **SAFEGUARD WATER**),
- technical risks originating from operating the system outside the design range may cause increased maintenance, repair and replacement costs,
- risk of theft and vandalism of the installation in a particular area, and
- financial risks related to poor water management (not enough water, or over-irrigation), equipment failures, etc.

The promoter should triangulate and compare information from different relevant sources:

- Manufacturers and technology service providers advertise and market their products intensively and outline their advantages and potentials – this information can be easily obtained from suppliers and system integrators, and via the websites of the manufacturers.
- Producer organizations may already have compiled or evaluated experiences of their members with a specific irrigation and pumping systems. They can also link up the promoter with other producers experienced with advanced technologies.
- International and national development stakeholders (including NGOs) may already have implemented and evaluated pilot projects based on the technology – this information should be available in sector working groups etc.

Recommendation: When approaching technology providers, producer organizations and development stakeholders for information, always ask for reference projects. A visit to these projects / installations and an information exchange with the operating producer is a worthwhile exercise.

Based on this information, the promoter will be able to establish a profile of the different technologies to be included in the promotion campaign. This profile will have to be specific with regard to:

- possibilities of employing the technology for a specific purpose;
- main benefits for the producer (impacts on irrigation operation, farm labor, crop production, market access, farm budget);
- main requirements and preconditions (water availability in the short and long run, land resources, works, adaptation of crop production and marketing, adaptation of irrigation operation, training needs);
- support mechanisms and offers (private sector service provision, extension and advisory services, promotion and subsidization schemes);
- potential negative impacts on the water table, environment, and socio-economic aspects.

PEOPLE STAKEHOLDERS

- Agricultural advisor / development practitioner;
- producer (organizations);
- wholesalers (purchasing agricultural products);
- Water Resource Management Authorities (management of water rights / licenses);
- organizations experienced with irrigation and solar pumping;
- technology provider.

OUTCOME / PRODUCT

- Analysis of availability, suitability, acceptability and supportability of technology options;
- profile of potentials and opportunities of each technology option;
- overview of framework conditions (i.e. water rights, subsidies, etc.);
- use the tool **PROMOTE – SPIS Rapid Assessment** for structured analysis.

DATA REQUIREMENTS

- Triangulation of different information sources with regard to technical, economic and environmental information.

IMPORTANT ISSUES

- The availability of a specific technology option may be limited (there may also be sub-regional differences).
- Triangulation (using different information sources) is required to obtain a realistic overview of potentials and opportunities.
- Assess the pros and cons of SPIS in the country, and/or project region, to have a strong knowledge base for the promotion of SPIS.

Innovative cultivation practices in irrigated farming

(Source: Andreas Hahn)

2. ANALYZE ACCESS TO FINANCE

In general, the introduction of modern irrigation technology requires comparatively high investments, which often go beyond the financial capacity of a farm household. This also applies to SPIS. This means that a promotion approach for irrigation technology must consider access to the required capital.

In order to finance investments in irrigation, the following sources, or a combination therefore exist:

- equity of the farm household;
- commercial loans and leasing (market conditions);
- subsidized (soft) loans to end borrower;
- group saving schemes and lending;
- subsidies and development grants;
- sponsoring.

Lack of external finance is often a limiting factor for medium sized farm households due to limited equity and limited credit rating with commercial financing institutions. Financing institutions are usually also very hesitant to open their loan portfolio to new technologies in the agricultural sector as the repayment duration for loans is usually long and risks exist with regard to crop failure. In addition, the lack of conventional loan collateral signifies an obstacle for banks. This is elaborated further in the **FINANCE** module that provides information and tools for financial service providers already financing or planning to finance SPIS

Knowledge about and connections to financial support for SPIS will be essential for promoters because potential SPIS users will be very much interested in this. The aspect of access to finance has to be a mandatory part of the initial analysis and information compilation of the promoter. At local level, producers often do not have access to information on alternative financing options for innovations.

Government has an important role to play in improving the framework conditions, such as minimizing market distortions, promoting private sector involvement, and supporting public goods and financial and physical infrastructures. One important tool for governments is **subsidies** to make modern irrigation technology available to medium-sized farm households. Subsidies usually exist for individual components of an irrigation system such as the pumping system (subsidies for PV pumping), water storage (subsidies for water tanks and farm ponds) and the irrigation system (subsidies for sprinkler and micro irrigation systems). They are mostly conditional (water and energy saving, cropping intensification) and time-bound, with a decreasing subsidy percentage over time.

The promoter needs to provide such information as part of his promotion material and subsequently as a basis for initiating projects. An important aspect is to not only provide information on the existence of financing sources, but to also provide information on how to access these.

With regard to potential follow-up activities related to the development of the financial sector response to modern irrigation financing the following guidelines are recommended by GPFI / IFC:

- Effective government support should be developed.
- Financial infrastructure should be strengthened (credit bureaus, improved collateral registries, alternative forms of collateral).
- Consistent and reliable data sources should be developed for end borrowers and financial operators (financing options and conditions, agricultural production,

supply chains, and market pricing information).

- Producers and financial service providers should be supported to increase knowledge and capacities with regard to financing modern irrigation solutions, so that they can come up with innovative solutions. These may include partial guarantee schemes and risk sharing facilities as an effective mechanism to foster lending for irrigation modernization purposes.

OUTCOME / PRODUCT

- Financing options information sheet (including conditions, institutions, contact details);
- recommendations for financing, options for a range of target groups.

DATA REQUIREMENTS

- Typical investment costs of technology options;
- information on financing options in the region;
- information on subsidy schemes in the region; information on donor and grant schemes.

PEOPLE / STAKEHOLDERS

- Agricultural advisor / development practitioner;
- financing institutions;
- governmental services;
- donors and donor-supported development projects.

IMPORTANT ISSUES

- Modern irrigation technology requires (partial) external financing.
- Subsidy schemes are often available to support the introduction of modern irrigation technology.
- ICT technology and / or regular information dissemination could be used to increase access to finance.

3. DEFINE TARGET GROUP AND STAKEHOLDERS

The analysis carried out in the preceding steps outline a profile of potential, opportunities, restrictions and risks with regard to the promotion of SPIS. The promoter should also have a good insight into the different forms of financial support for financing SPIS. While some farm household may have access to commercial financing services, others may require a 100% subsidy or a grant to introduce the technology to their farm.

Based on the analysis, the promoter will have to define a specific target group for the technology options promoted. Targeting a specific market does not mean that you are excluding people who do not fit your criteria. Rather, target marketing allows you to focus your marketing dollars and brand message on a specific market that is more likely to buy from you than other markets. This is a much more affordable, efficient, and effective way to reach potential clients and generate business. No one can afford to target everyone.

In case of the SPIS technology this concerns usually medium-sized farm households with good market access and a potential to adapt and intensify their production. Large farm enterprises usually obtain the required information directly through private sector service providers and take investment decisions based on their own business planning (and own equity financing).

Small-scale farmers with poor access to markets and subsistence farm households often cannot cope with the operational requirements and related costs that come with high investments such as induced by SPIS options, even though they may benefit from subsidies or grants. Group schemes with shared pumping installations are an alternative to individual systems in case of smallholders or subsistence producers. This option can also cater for the need to promote disadvantaged and impoverished farming communities that may only have access to communal land. In many cases this women and youth a chance to have land rights, which is often a pre-condition for them to access credit and equity financing.

The preceding analysis also reveals the identification of important stakeholders for the promotion:

- technology supplier and service providers - to provide proof of well functioning SPIS configurations;
- financing institutions - to give access to funds to finance SPIS;
- agricultural extension services and service providers - to promote the technology and to optimize the productivity and profitability;
- government institutions managing subsidy schemes - to create awareness on support options and improve access to subsidies and other support;
- producer organizations and groups - to create economies of scale for purchasing, selling and accessing information and services;
- donors and NGOs - to support accessing services, improve organizational capacity, and to pilot and demonstrate SPIS configurations.

The identified stakeholders and their role (actual and potential) should be listed as part of the information compilation. Some of these stakeholders may also assume the role as a multiplier of information in the promotion campaign.

OUTCOME / PRODUCT

- Defined range (size) of target farm households and additional criteria (market access, intensification potential);

- list of stakeholders with roles and responsibilities.

DATA REQUIREMENTS

- Farm household / enterprise profiles in the promotion area;
- functions and functioning of stakeholders.

PEOPLE / STAKEHOLDERS

- Agricultural advisor / development practitioner.

IMPORTANT ISSUES

- Not every farm enterprise can absorb an investment in modern irrigation technologies due to limited market access and potential to adapt and intensify production.
- Group schemes with shared pumping facilities can be a feasible approach for subsistence producers, disadvantaged communities and for women and young people with access to resources.

Farmer group meeting

(Source: Lennart Woltering)

4. DEFINE A PROMOTION STRATEGY

Deciding on a promotion strategy is one of the primary roles of the promoter and this process involves some key decisions about who the customers are, how to contact them, and what the message should be. From the previous steps the target group and its priorities and needs became clear. Now it is important to decide if you want to use the press, advertising (or other media) or personal contact to reach them. Then you need to be clear what your (unique) selling points are in order to create a demand for the promoter services.

In almost any country around the world experience exists with regard to promotion and awareness raising campaigns in the agricultural sector. Successful approaches may be proposed by the extension services and development partners such as donors and NGOs. Appropriate approaches are always target group focused and culturally sensitive. Particular attention has to be given to information access for disadvantaged communities and in particular women and young people. Dissemination meetings and seminars etc. are traditionally dominated by male household heads and lead producers.

Promotion activities should include communicative and interactive instruments as the simple dissemination of information sheets and brochures is often not sufficient to reach all target households.

Possible activities are for example:

- producer field days and producer technology fairs (this can also be organized in cooperation with technology service providers);
- “village road shows” with technology presentations on village level;
- extension seminars with lead producers as multipliers.

Recommendation: Wherever possible, technology suppliers and NGOs should be incorporated into the promotion concept as they can provide valuable information. An agreement needs to be reached as to the impartiality of information provision. It is also advisable to invite representatives of local banks / financing institutions to promotion events in order to contribute to their awareness for the new technologies.

Furthermore, a number of passive dissemination means exist, which also require a very thorough preparation of materials:

- rural radio bulletins;
- short bulletins on the local TV;
- preparation of posters;
- internet videos (posting via YouTube etc.).

Depending on the promotion approach and instruments chosen, the compilation of promotion material can be a significant task. It should include a target group-specific design and layout of documents etc. Sufficient budgetary resources must be available in order to produce good quality promotion material. In addition, the promoter should be well aware of the proper capacity (human resources and financial) to set up and implement a good promotion campaign.

Important: When approaching the promotion of irrigation technology, the prime objective of the promotion effort must always provide the producer with information that enables him to take a decision in view of securing and / or increasing his production potential. Promotion from a development perspective is not marketing of a specific product!

OUTCOME / PRODUCT

- Determination of promotion approach and instruments;
- agreement with relevant stakeholders on cooperation activities;
- design and layout of promotion material.

DATA REQUIREMENTS

- Experiences with different promotion approaches and instruments (agricultural sector);
- own human resources and financial capacity to undertake a promotion campaign.

PEOPLE / STAKEHOLDERS

- Agricultural advisor / development practitioner;
- technology provider;
- producer organizations;
- donors and NGOs;
- financial service providers.

IMPORTANT ISSUES

- Promotion activities should include communicative and interactive instruments.
- Information access to disadvantaged communities, women and young people has to be considered.
- Technology suppliers and NGOs should be incorporated into the promotion concept as they can provide valuable information.

5. PLAN AND IMPLEMENT PROMOTION ACTIVITIES

The implementation of promotion activities should only be started once the required promotion material is developed and available. Ideally, an interactive focus is the foundation of the promotion campaign, which means that planning for the implementation of activities must be done well in advance and in a joint effort with the cooperating partners. At many times of the year, most producers have very limited time to attend seminars and meetings. The planning should therefore be oriented on the agricultural calendar and the regional work peaks. This way good participation can be achieved. Particular attention should be paid to the limited time resources of women and youth.

Planning should also include the identification of suitable presenters or trainers, who have experience with the particular target group. A recommended approach is the inclusion of lead producers as multiplier and co-presenters for dissemination meetings. In order to access women and young people, a balance of gender and seniority must be introduced to the promotion team. The incorporation of staff from local NGOs, for example, may be conducive to the success of the activities. Promoter and presenters should not only be familiar with the promotion material and the objectives and key messages of the campaign, but should also be trained in carrying out extension meetings etc. Local events should be announced in advance to encourage greater participation.

Announcements may be disseminated through:

- black board announcement at the agricultural extension bureau;
- distribution of flyers;
- technology provider shops;
- local newspaper;
- rural radio services;
- SMS-services.

The implementation of the promotion events should always position the producer into the centre of the extension concept. The objective of each event is not only to provide information based on an anticipation of producers' needs, but to allow for practical demonstration, questions, discussions and a capture of the producers' expectations and needs.

Feedback from the participants of the promotion and extension events should be obtained in a systematic way to further develop the didactics. A good documentation of feedbacks and interests / needs for further information will enable an efficient and targeted follow-up at a later stage.

OUTCOME / PRODUCT

- Schedule / plan for local promotion and extension events based on agricultural calendar;
- announcements via flyer / posters local media;
- captured feedback and further information and follow-up requests from the producers.

DATA REQUIREMENTS

- Information on local work peaks in agriculture;
- information on suitable venues / areas for promotion events;
- information on other extension events;
- contact information of important local stakeholders such as banks / financing institutions, producer organizations, NGOs, private sector associations etc. (to be invited).

PEOPLE / STAKEHOLDERS

- Agricultural advisor / development practitioner;
- producer;
- technology provider;
- producer organizations;
- financial service provider;
- donors and NGOs.

IMPORTANT ISSUES

- Producers should be encouraged to interact with the promoters / presenters to ask questions, provide feedback and to articulate further needs / information requirements.
- Producer feedback and further information requirement should be documented.

Field visit to a SPIS site in India

(Source: Lennart Woltering)

6. SECURE FOLLOW-UP

Promotion activities may result in further information requirements and first expressions of interest for the new technology. In many areas the service structure of technology suppliers and their associated installation service providers is not very well developed. Very often, the supplier maintains only a few (if not only one) branches in the country. For many producers interested in modern technology options such as SPIS it is not feasible to travel to the capital to obtain further information. It is therefore required to properly document contract requests and information needs during the promotion and extension events and to provide the producers with contact details for further consultation.

The promoter should process the documented producer's requests in a systematic way and follow-up action should take place without delay after the first contact during the promotion event. With the follow-up after the promotion activity the initiation of a possible future project starts. Now the promoter has to choose how to pursue the follow-up. Possible scenarios are:

- initiation of direct information and contact between the producer and a technology provider / project developer;
- recommendation of follow-up activities to locally operating development partners (NGOs, donors).

The next steps in this initiation process will be a first assessment of the suitability of different technology options in the specific farm context. This requires a physical site visit and a deeper joint reflection process together with the producer. The following modules of this toolbox, in particular the **DESIGN**, **SET UP** and **MAINTAIN** processes, assist the advisor and development practitioner to carry out this preliminary assessment.

OUTCOME / PRODUCT

- Contact between producer and service provider / development partner for follow-up activities;
- initiation of project development activities.

DATA REQUIREMENTS

- Contact details of producer and service provider / development partner for project development.

PEOPLE / STAKEHOLDERS

- Agricultural advisor / development practitioner;
- producer;
- technology provider;
- donors and NGOs.

IMPORTANT ISSUES

- Technology suppliers often do not maintain an extensive network of branch offices, requiring proactive contact management.
- Follow-up activities should be carried out timely after the request for further information to maintain the confidence of the producer.

FURTHER READING, LINKS AND TOOLS

Further reading

Hahn, A., Sass, J. & Fröhlich, C. (2015): Manual and tools for promoting SPIS. Multicountry - Stocktaking and Analysis Report. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved on https://energypedia.info/wiki/Solar_Powered_Irrigation_Systems_-_Technology,_Economy,_Impacts

International Finance Corporation (2011): Scaling Up Access to Finance for Agricultural SMEs Policy Review and Recommendations. Retrieved on https://www.gpfi.org/sites/default/files/documents/G20_Agrifinance_Report%20(FINAL%20ONLINE).pdf

SPIS tools

PROMOTE – SPIS Rapid Assessment

TECHNICAL GLOSSARY

Aquifer	Underground geological formation(s), containing usable amounts of groundwater that can supply wells or springs for domestic, industrial, and irrigation uses.
Chemigation	The process of applying chemicals (fertilizers, insecticides, herbicides, etc...) to crops or soil through an irrigation system with the water.
Conveyance loss	Loss of water from a channel or pipe during transport, including losses due to seepage, leakage, evaporation, and other losses.
Crop coefficient	Ratio of the actual crop evapotranspiration to its potential (or reference) evapotranspiration. It is different for each crop and changes over time with the crop's growth stage.
Crop Water Requirement (CWR)	The amount of water needed by a plant. It depends on the climate, the crop as well as management and environmental conditions. It is the same as crop evapotranspiration.
Current (I)	Current is the electrical flow when voltage is present across a conductor, or the rate at which charge is flowing, expressed in amperes [A].
Deep percolation	Movement of water downward through the soil profile below the root zone. This water is lost to the plants and eventually ends up in the groundwater. [mm]
Drawdown	Lowering of level of water in a well due to pumping.
Drip irrigation	Water is applied to the soil surface at very low flow rates (drops or small streams) through emitters. Also known as trickle or micro-irrigation.
Emitter	Small micro-irrigation dispensing device designed to dissipate pressure and discharge a small uniform flow or trickle of water at a constant discharge which does not vary significantly because of minor differences in pressure head. Also called a "dripper" or "trickler".
Evaporation	Loss of water as vapor from the surface of the soil or wet leaves. [mm]
Evapotranspiration (ET)	Combined water lost from evaporation and transpiration. The crop ET (ETc) can be estimated by calculating the reference ET for a particular reference crop (ETo for clipped grass) from weather data and multiplying this by a crop coefficient. The ETc, or water lost, equals the CWR, or water needed by plant. [mm]
GIWR	The Gross Irrigation Water Requirement (GIWR) is used to express the quantity of water that is required in the irrigation system. [mm]
Infiltration	The act of water entering the soil profile.
Fertigation	Application of fertilizers through the irrigation system. A form of chemigation.

Financial viability	The ability to generate sufficient income to meet operating expenditure, financing needs and, ideally, to allow profit generation. It is usually assessed using the Net Present Value (NPV) and Internal Rate of Return (IRR) approaches together with estimating the sensitivity of the cost and revenue elements (See Module **FINANCE**).
Friction loss	The loss of pressure due to flow of water in pipe. It depends on the pipe size (inside diameter), flow rate, and length of pipe. It is determined by consulting a friction loss chart available in an engineering reference book or from a pipe supplier. [m]
Global solar radiation (G)	The energy carried by radiation on a surface over a certain period of time. The global solar radiation is locations specific as it is influenced by clouds, air humidity, climate, elevation and latitude, etc. The global solar radiation on a horizontal surface is measured by a network of meteorological stations all over the world and is expressed in kilowatt hours per square meter [kWh/m^2].
Gravity flow	The use of gravity to produce pressure and water flow, for example when a storage tank is elevated above the point of use, so that water will flow with no further pumping required.
Head	Value of atmospheric pressure at a specific location and condition. [m]: Head, total (dynamic) Sum of static, pressure, friction and velocity head that a pump works against while pumping at a specific flow rate. [m]; Head loss Energy loss in fluid flow. [m]
Insolation	The rate at which solar energy reaches a unit area at the earth measures in Watts per square meter [W/m^2]. Also called solar irradiance.
Irradiation	The integration or summation of insolation (equals solar irradiance) over a time period expressed in Joules per square meter (J/m2) or watt-hours per square meter [Wh/m^2].
Irrigation	Irrigation is the controlled application of water to respond to crop needs.
Irrigation efficiency	Proportion of the irrigation water that is beneficially used to the irrigation water that is applied. [%]
Irrigation head	Control unit to regulate water quantity, quality and pressure in an irrigation system using different types of valves, pressure regulators, filters and possibly a chemigation system.
Lateral	Pipe(s) that go from the control valves to the sprinklers or drip emitter tubes.
Latitude	Latitude specifies the north–south position of a point on the Earth's surface. It is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles. Lines of constant latitude, or parallels, run east–west as circles parallel to the

	equator. Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.
Leaching	Moving soluble materials down through the soil profile with the water.
Maximum Power Point Tracking (MPPT)	An important feature in many control boxes to draw the right amount of current in order to maintain a high voltage and achieve maximum system efficiency.
Net Irrigation Water Requirements (NIWR)	The sum of the individual crop water requirements (CWR) for each plant for a given period of time. The NIWR determines how much water should reach the crop to satisfy its demand for water in the soil. [mm]
Power (P)	Power is the rate at which energy is transferred by an electrical circuit expressed in watts. Power depends on the amount of current and voltage in the system. Power equals current multiplied by voltage (P=I x V). [W]
Photosynthesis	Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation).
Pressure	The measurement of force within a system. This is the force that moves water through pipes, sprinklers and emitters. Static pressure is measured when no water is flowing and dynamic pressure is measured when water is flowing. Pressure and flow are affected by each other. [bars, psi, kPa]
Priming	The process of hand-filling the suction pipe and intake of a surface pump. Priming is generally necessary when a pump must be located above the water source.
Pump	Converts mechanical energy into hydraulic energy (pressure and/or flow). Submersible pump: a motor/pump combination designed to be placed entirely below the water surface. Surface pump: pump that is not submersible and placed not higher than about 7 meters above the surface of the water.
Root Zone	The depth or volume of soil from which plants effectively extract water from. [m]
Salinity (Saline)	Salinity refers to the amount of salts dissolved in soil water.
Solar panel efficiency	Solar panel efficiency is the ratio of light shining on the panel, versus the amount of electricity produced. It is expressed as a percentage. Most systems are around 16% efficient, meaning 16% of the light energy is converted into electricity.
Suction lift	Vertical distance from the surface of the water to the pump. This distance is limited by physics to around 7 meters and should be minimized for best results. This applies only to surface pumps.
Surface irrigation	Irrigation method where the soil surface is used to transport the water via gravity flow from the source to the plants. Common

	surface irrigation methods are: Furrow irrigation – water is applied to row crops in small ditches or channels between the rows made by tillage implements; Basin irrigation – water is applied to a completely level area surrounded by dikes, and Flood irrigation – water is applied to the soil surface without flow controls, such as furrows or borders.
Transpiration	Water taken up by the plant's roots and transpired out of the leaves. [mm]
Voltage (U or V)	Voltage is the electric potential between two points, or the difference in charge between two points, expressed in Volts [V].