A GUIDE ON

INNOVATIVE AGRICULTURAL/IRRIGATION PRACTICES AND TECHNOLOGIES FOR EFFICIENT WATER MANAGEMENT

NATIONAL PROGRAM MANAGEMENT UNIT
ATAL BHUJAL YOJANA
MDSS (MTNL) Building, 9 CGO Complex,
Opp. Gate No. 13, JLN Stadium, New Delhi - 110003

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Under

ATAL BHUJAL YOJANA

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1. BACKGROUND

Irrigation is the largest user of water accounting about 70% of global freshwater withdrawals. Increasing food, feed, fibre and bio-fuel demand by continued population growth is handled by expanding irrigated areas, especially in developing countries. However, there has been mounting pressure to limit water supply to irrigated agriculture and to produce more food with less water. Consequently, the search for technologies/ measures to save/ conserve water in irrigated agriculture has intensified.

In last three decades, India has seen a spurt in ground water usage for irrigation, putting tremendous pressure on the sustainability of ground water sources. Atal Bhujal Yojana is an unique initiative for improved management of ground water through community involvement. Demand side management is at the core of the Atal Bhujal Yojana and one of the important aspects is 'innovations in agriculture / Irrigation Practices to reduce ground water withdrawal".

The traditional practices of water savings in irrigation and agriculture has made substantial difference, however, the time has come to use more advanced time tested techniques and practices. It has been observed that the interventions proposed by the Gram Panchayats in the Water Security Plans are limited to drip, sprinkler, underground pipes and crop diversification. Though these interventions are crucial and relevant to most of the area, it is of paramount importance to introduce certain innovative interventions that are evidence based and happening in other parts of the country.

Such innovations are cost effective and easily adaptable and replicable. Many of them come under 'Good Agriculture Practices', the literature and related trainings can be converged from the agriculture, horticulture departments – KVKs, Agricultural Technology Management Agency (ATMA), Universities and various organizations working in the country.

Under the institutional convergence concept of Atal Bhujal Yojana, it is being ensured that all the line departments at the state level such as agriculture, Irrigation, Horticulture and Sericulture departments are on board and all necessary facilities are leveraged for promoting the innovative practices.

Thorough this guide , an attempt has been made to run through the time tested innovative agricultural / irrigation best practices and technologies towards efficient irrigation which will eventually reduce the ground water demand and improve the ground water.

This guide will certainly provide a handy tool for agriculture practitioners and progressive farmers to adopt newer technologies and practices in agriculture farming.

2. Paddy cultivation through innovative practices

A. Direct seeding of rice (DSR):

DSR refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeding can be done by sowing pre-germinated seed into puddled soil (wet seeding) or standing water (water seeding) or a prepared seedbed (dry seeding).

Water Saving: Savings on irrigation water by 12-35% under efficient water management practices

a) Dry DSR: In Dry-DSR, rice is established using several different methods, including (i) broadcasting of dry seeds on unpuddled soil after either Zero Tillage (ZT) or Conservation Tillage(CT) (ii) dibbled method in a well-prepared field, and (iii) drilling of seeds in rows after Conservation Tillage, minimum tillage (MT) using a power tiller-operated seeder, ZT or raised beds. In the case of both CT or ZT, a seed-cum-fertilizer drill is used, which, after land preparation or in ZT conditions, places the fertilizer, and drills the seeds.

b) Wet DSR: Wet-DSR involves the sowing of pregerminated seeds (radicle 1- 3 mm) on or into puddled soil. When pregerminated seeds are sown on the surface of puddled soil, the seed environment is mostly aerobic, and this is known as aerobic Wet-DSR. When pregerminated seeds are sown/drilled into puddled soil, the seed environment is mostly anaerobic, and this is called anaerobic Wet-DSR. Wet-DSR under aerobic and anaerobic, seeds can either be broadcasted or sown in-line using a drum seeder[81] or an anaerobic seeder with a furrow opener and closer.[6]

Advantages of Direct-Seeded Rice:

- ✓ No significant reduction of yield under optimal conditions
- ✓ Savings in labour (40–45%), **water (30–40%),** fuel/energy (60–70%), and reductions in greenhouse gas emissions
- ✓ Reduces labour and drudgery by eliminating seedling uprooting and transplanting
- ✓ Reduces cultivation time, energy, and cost
- ✓ No plant stress from transplanting
- ✓ Faster maturation of crops
- ✓ Lower GHG emissions
- ✓ Increases total income by reducing the cost of cultivation
- ✓ DSR is also being considered for carbon credit generation. It may provide additional benefits to farmers.

Literature for more information:
https://www.agriculturejournal.org/volume5number1/direct-seeded-rice-prospects-problemsconstraints-and-researchable-issues-in-india/

https://www.researchgate.net/publication/328079045_Water_balance_in_direct-seeded_rice_under_conservation_agriculture_in_North-western_Indo-Gangetic_Plains_of_India
https://ricetoday.irri.org/tar-vattar-dsr-an-eco-friendly-weed-control-and-water-conservation-technology-for-dry-seeded-rice/
https://ricetoday.irri.org/organic-hydrogel-technology-helps-boost-dry-seeding-of-rice-in-northwestern-india/

B. **Alternate wetting and drying (AWD) paddy cultivation:**

Alternate wetting and drying (AWD) are a water-saving technology that lowland (paddy) rice farmers can apply to reduce their water use in irrigated fields. In AWD, irrigation water is applied to flood the field a certain number of days after the disappearance of ponded water. Hence, the field is alternately flooded and non-flooded. The number of days of non-flooded soil in AWD between irrigations can vary from day one to more than ten days depending on the soil type.

It is done by monitoring the depth of ponded water on the field using a 'field water tube.' After flooding, the depth of pounded water will gradually decrease. When the ponded water has dropped to 15 cm below the surface of the soil, irrigation should be applied to re-flood the field with 5 cm of ponded water. This practice is known as Safe AWD.

Water saving- Water savings may be up to 15 to 25 percent with no yield penalty.

Advantages of AW&D:

- ✓ Water savings may be up to 15 to 25 percent with no yield penalty.
- ✓ AWD promotes good root anchorage, thus reduction in plant lodging problems.
- ✓ In pump irrigation systems, it reduces pumping costs and fuel consumption and an increased income of USD 67 to USD 97 per hectare.
- ✓ It reduces 30 to 70 percent of methane emissions depending on the combination of water usage and management of rice stubble.
- ✓ It also promotes higher zinc availability in soil and grains by enabling periodic aeration of the soil, which releases zinc from insoluble forms and makes it available for plant uptake.
- ✓ AWD is a water-saving technology for lowland (paddy) rice production under irrigation.

Literature for more information:

https://teca.apps.fao.org/teca/en/technologies/7939#:~:text=Alternate%20wetting%20and%20drying%20(AWD,the%20disappearance%20of%20ponded%20water.

Resourceful organisation for these practices:

- International rice research institute- https://www.irri.org/
- State agriculture universities
- Dept of Agriculture

3. Plastic Mulching:

Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development, and efficient crop production. Mulch technical term that means 'covering of soil.'

Plastic mulching is a thin film of polyethylene used to cover up the soil. Polyethylene is preferred because of its greater permeability to longwave radiation which can increase the temperature around plants during the night times. Mulch film comes in diverse colours, size, and thickness.

Mulch laying machine: Plastic Mulch Laying Machine is an effective implement for laying mulches in the field.

Water saving- 40 % saving of water by checking soil surface evaporation and 90 % control of weed

Advantages of plastic mulching:

Moisture conservation:

- ✓ Plastic film with its moisture barrier properties does not allow the soil moisture to escape water that evaporates from the soil surface under mulch film, condenses on the lower surface of the film, and falls back as droplets.
- ✓ Thus, moisture is preserved for several days and increases the period between two irrigations.
- ✓ By evaporation suppression, it prevents the rise of water-containing salts

Weed control

- ✓ Black plastic film does not allow the sunlight to pass through onto the soil
- ✓ Photosynthesis does not take place in the absence of sunlight below black film; hence, it arrests weed growth

Yield enhancement:

- ✓ Mulching through a better microclimate helps in enhancing the yield of crops

Availability: Plastic mulching as well as mulch laying machines are commercially available

Literature for more information:

http://www.agritech.tnau.ac.in/agricultural_engineering/plastic_mulching.pdf
https://pdfs.semanticscholar.org/a1b3/66b0e40c53c4419a060f64d7cc8ddb300ab4.pdf
https://www.researchgate.net/publication/336394101_Mulching_as_water-saving_technique_in_dryland_agriculture_review_article

4. Hydrogel:

Hydrogels are macromolecular cross-linked hydrophilic polymeric chains with the ability to absorb water or aqueous fluids. Hydrogel retains water in-ground soil, reduces the frequency of required watering, and enhances the healthy growth of trees and plants.

Hydrogel works as water reservoirs around the root mass zones of the plant. In presence of water, it expands to around 200-800 times the original volume. When the polymers come in contact with water, the water penetrates the hydrogel system by osmosis. When the surrounding around the root zone begins to dry up, the hydrogel gradually dispenses up to 95% of its stored water to plant absorption. Under exposition to rewetting conditions, rehydration starts and the process of storing water continues. This polymer has the ability to increase water retention in soil which facilitates higher water uptake and water use efficiency, thus helping in reducing the water stress of plants and increasing crop growth and yield. The hydrogels are biodegradable and decompose in the soil after working for 2-5 years and thus do not alter the physicochemical properties of the soil.

Water saving- May help in the survival of crops for 10-15 days long dry spell

Benefits:

- ✓ Hydrogels function as “miniature water reservoirs” near the root zone of plants. It can absorb both natural and supplied water and release it slowly on water shortage conditions by root capillary suction mechanism
- ✓ It can decrease soil osmotic moisture; save irrigation water, labour, and production cost; reduce irrigation requirement of crops; mitigate drought conditions; prevent leaching and runoff of water and nutrients; improve water and nutrient use efficiencies in plants, and restore soil microorganisms and enzymes
- ✓ It can help the plant to withstand the prolonged moisture stress by delaying the onset of permanent wilting of the plant

Availability: Hydrogel are commercially available in the market for use in agriculture

Literature:

https://www.vigyanvarta.com/adminpanel/upload_doc/VV_1220_16.pdf
https://www.nature.com/articles/s41598-022-16049-x
https://www.hindawi.com/journals/ijps/2022/4914836/

5. Broad bed furrow (BBF) cultivation:

The Broad Bed and Furrow system has been developed at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in India. The recommended ICRISAT system consists of broad beds about 100 cm wide separated by sunken furrows about 50 cm wide. The preferred slope along the furrow is between 0.4 and 0.8 percent on vertisols. Two, three, or four rows of crop can be grown on the broad bed, and the bed width and crop geometry can be varied to suit the cultivation and planting equipment.

Prepration of broad beds

Rainwater in furrows

Crop stand with BBF planting

FIRB planting in wheat

Water saving: The results of a study done by ICRISAT show that the soil water content is higher in broad bed furrows by 4-10% depending on soil depths, and the depletion of soil water through plant uptake was higher, indicating its efficiency.

Merit of BBF cultivation:

- ✓ It encourages moisture storage in the soil profile and conserves soil moisture in dryland
- ✓ It disposes of surplus surface run-off without causing soil erosion. It Acts as a drainage channel during heavy rainy days
- ✓ It provides better drained and more easily cultivated soil in the beds.

Availability: BBF machine is commercially available in the market

Literature for more information:

http://sadhanafarm.blogspot.com/2016/08/water-conservation-broad-bed-and-furrow.html
https://www.icrisat.org/broad-bed-furrows-save-water-and-increase-crop-productivity-says-an-icrisat-study/
https://agritech.tnau.ac.in/agriculture/agri_majorareas_dryland_enggmeasures_bbf.html
http://researchjournal.co.in/upload/assignments/10_297-301.pdf
https://www.researchgate.net/publication/326082446_Broad_Bed_and_Furrow_Technique-A_Climate_Smart_Technology_for_Rainfed_Soybean_of_Marathwada_Region

6. Composting:

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes, and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

Water saving: Compost use in the soil increases the water-holding capacity of the soil.

Following are scalable methods of composting

a) **Waste decomposer-based composting:** It is a consortium of few beneficial microorganism extracted from desi cow dung. It was launched by National centre for organic and natural farming (NCONF).
This is a cost-effective technique as it demands neither standard structure nor essential parameters which are compulsory in other composting method. The price of one bottle of culture is only Rs 20 which has shelf life of 3 years. Other conventional methods take 8-10 month to fully decompose the material in to compost while it requires only 55-60 days for the same.

b) **Vermicomposting using vermibeds:** It is the decomposition of organic material (plant and or animal origin) by earthworms. Vermicompost is organic matter of plant and/or animal origin consisting mainly of finely divided earthworm castings.
Now a days Vermi beds are more popular than conventional pit structure due to being portable in nature. These are HDPE-made low-cost structure that comes in a range of Rs 1500-3000 per bed and are durable too.

Advantages of using compost in agriculture:

- ✓ Increases the water-holding capacity of the soil directly by binding water to organic matter, and indirectly by improving the soil structure, thus improving the absorption and movement of water into the soil. Therefore, water requirements and irrigation will be reduced.
- ✓ Protects the surface soil from water and wind erosion by reducing the soil-dispersion action of beating raindrops, increasing infiltration, reducing water runoff, and increasing surface wetness. Preventing erosion is essential for protecting waterways and maintaining the quality and productivity of the soil.
- ✓ Helps moderate soil temperature and prevents rapid fluctuations of soil temperature, hence, providing a better environment for root growth.

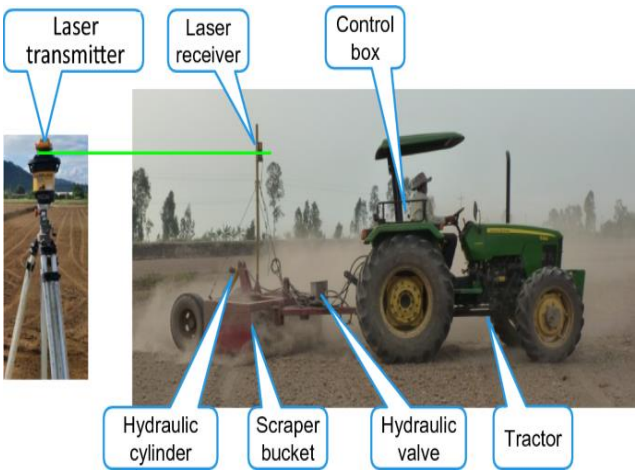
Availability: Waste decomposer is available at IFFCO centres in each district. Vermibeds are commercially available in the market.

Literature for more information:

https://icar-nrri.in/wp-content/uploads/2020/07/143_VERMI-COMPOST-Final.pdf
https://agricoop.nic.in/sites/default/files/Vermicompost%20Production%20Unit.pdf
https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=16800#:~:text=Compost%20also%20reduces%20plants'%20needs,the%20soil's%20water%20holding%20capacity
https://pib.gov.in/PressReleasePage.aspx?PRID=1517696

7. Laser land levelling:

Laser levelling is a process of smoothing the land surface (± 2 cm) from its average elevation using laser-equipped drag buckets. This practice uses large horsepower tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser-guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level. This technique is well known for achieving higher levels of accuracy in land levelling and offers immense potential for water savings and higher grain yields. Precision land levelling involves altering the fields in such a way as to create a constant slope of 0 to 0.2%.



Water saving: As per study, Impacts of Laser Land Levelling in Rice-Wheat Systems of the Northwestern Indo-Gangetic Plains of India, by researchers from the International Maize and Wheat Improvement Centre (CIMMYT), Borlaug Institute for South Asia (BISA) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS

- Laser land levelling lowers irrigation time for rice by 47-69 hours per hectare per season and for wheat by 10-12 hours per hectare per season.
- It saves electricity about 755 kWh per hectare per year for rice-wheat systems

Advantages of Laser land levelling:

- A precisely levelled surface leads to uniform soil moisture distribution, resulting in good germination, enhanced input use efficiency, and improved crop stand and yield
- Laser levelling allows for control of water distribution with negligible water losses.
- Laser levelling improves irrigation efficiency and reduces the potential for nutrient loss through better irrigation and runoff control
- It facilitates uniformity in the placement of seedlings, helping to achieve higher yields.
- Land levelling reduces weed (improved water coverage reduces weeds up to 40%), pest, and disease problems.
- It results in 3 to 4% additional land recovery and improves operational efficiency (reducing the operating time by 10% to 15%).
- Leads to reduced consumption of seeds, fertilizers, chemicals, and fuel
- Facilitates movement of agricultural machinery through the fields

Availability: The machine is commercially available in the market.

Literature for more information:

http://www.jnkvv.org/PDF/14042020234416irri-cimmyt-laser-land-leveling.pdf
https://ccafs.cgiar.org/news/laser-land-levelling-how-it-strikes-all-right-climate-smart-chords
https://www.techno-preneur.net/technology/new-technologies/Mechine/Laser.htm
https://khetigaadi.com/blog/laser-land-leveling/

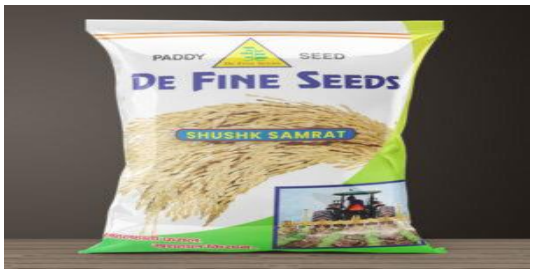
8. Crop diversification:

Crop diversification can be defined as an attempt to promote crop diversity by crop rotation, multiple cropping, or intercropping, with the goal of improving productivity, sustainability, and supply of the ecological system. Enhanced agricultural diversity, better diverse crop rotations, mixed cropping cultivation of grain legumes in cereal-dominated systems, and regionally adapted varieties or variety combinations are all examples of agricultural diversification strategies.
For increasing water use efficiency, crop diversification with rainfed horticulture crops as well as diversification with low water demanding crops and varieties including short duration could be good strategy.

a) **Crop diversification with rainfed horticulture crops:** Rainfed horticulture once established can be maintained on conserved moisture or less water than seasonal crops. Seasonal crops require equal amount of water every year. Ber, Date palm, Aonla, Guava, Pomegranate, Acid lime are some of the crops which are hardy in nature and have low water demand.

b) **Diversification with hardy and low water consuming crops:** Millet, Pulses and Oilseed crops are hardier and less water-intensive crops than cereals. High yielding varieties of these crops can be promoted as intercrop or mixed crop. Diversity in cropping also helps in mitigating risk during adverse climatic conditions.

c) **Diversification with short duration and hardy crop varieties:** Promotion of short-duration and stress/drought-tolerant varieties can also help in reducing irrigation water requirements. These varieties can withstand the dry spell in kharif season and can also be grown on conserved moisture in rabi season.



Advantages of crop diversification:

- Better resource use efficiency especially for water
- Crop diversification also helps in mitigating risks during price fluctuation and adversities of climate conditions
- Horticulture crops fetch higher revenue than grain crops and hence, increase the farm and farmer's income

Availability: District Agri & Horti depts, State agriculture universities, CGIAR institutes, Open market

Literature for more information:

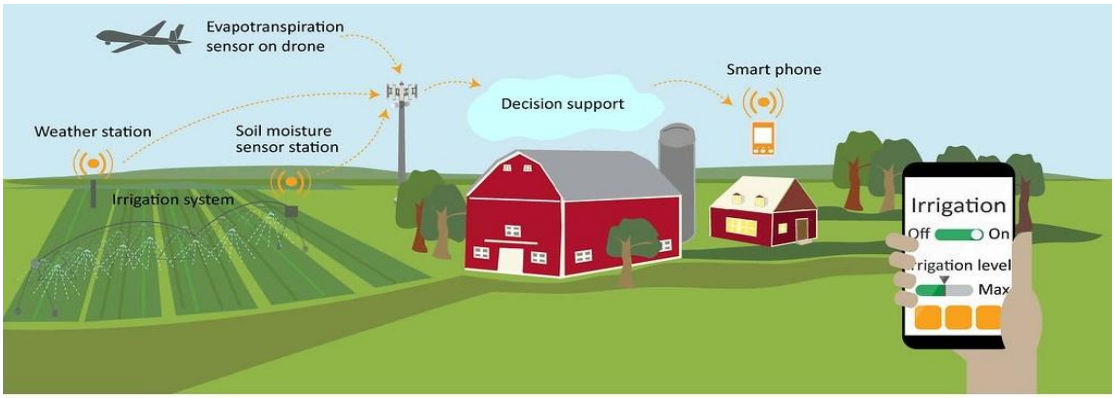
https://www.intechopen.com/chapters/81179
https://icar.org.in/sites/default/files/Crop%20diversification.pdf
https://www.currentscience.ac.in/Volumes/120/08/1303.pdf
https://www.researchgate.net/publication/301319756_Crop_diversification_and_risk_management_in_Indian_agriculture

9. Smart irrigation technologies:

Smart irrigation technology uses weather data or soil moisture data to determine the irrigation need of the landscape. These technologies maximize irrigation efficiency by reducing water waste, while maintaining plant health and quality.

Following two sensor-based irrigation are popular now a days

- **Weather-Based Controllers**: Weather-based controllers also referred to as evapotranspiration (ET) controllers use local weather data to adjust irrigation schedules. Evapotranspiration is the combination of evaporation from the soil surface and transpiration by plant materials. These climate-based controllers gather local weather information and make irrigation run-time adjustments, so the landscape only receives the appropriate amount of water.



- **Soil Moisture Sensor Controllers:** soil moisture sensor controllers utilize a soil moisture sensor placed belowground in the root zone of field to determine water need. The soil moisture sensor estimates the soil volumetric water content. Volumetric water content represents the portion of the total volume of soil occupied by water. The controllers can be adjusted to open the valves and start irrigation once the volumetric water content reaches a user-defined threshold.

Water saving: Several controlled research studies indicate substantial water savings anywhere from 30 to 50 percent.

Advantages:

- ✓ Reduced water consumption
- ✓ Increase in productivity
- ✓ No manpower required
- ✓ Safe
- ✓ Reduce soil erosion and nutrient leaching

Availability: Many start-ups in India are providing these technologies. These technologies may be customised as per the requirement.

Literature for more information:

https://extension.okstate.edu/fact-sheets/smart-irrigation-technology-controllers-and-sensors
https://www.hydropoint.com/what-is-smart-irrigation/
https://ijariie.com/AdminUploadPdf/SMART_IRRIGATION_1466.pdf
https://fasal.co/

10. Green House:

Greenhouse is a framed structure covered with glass or plastics film (transparent and translucent) in which plants are grown under the partially or fully controlled environment. The greenhouse technology has been considerable importance in better space utilization, growing crops in extreme climatic conditions and high rainfall areas. The plastics film used in greenhouse act as selective radiation filters. The solar radiations pass through it and trap the thermal energy inside the greenhouse, which is emitted by the objects that are kept inside, this phenomenon is known as "greenhouse effect".

Water saving: Greenhouse farming reduces water consumption as compared to open-air farming for four primary reasons: 1) plants lose less water through evapotranspiration, due to the decreased wind, increased humidity, and regulated temperature in the greenhouse environment, 2) drip irrigation systems improve the efficiency of water usage, 3) crops are spaced more closely, thus reducing water wastage, and 4) the crop cycle in a greenhouse is typically shorter than in the open-air, resulting in less water used over the entire growing season

Advantages:

- Moderates' temperature and humidity.
- Increases yield, quality and reduces crop duration.
- **Conserve moisture thus needs less irrigation.**
- Cultivation of off-season crops possible.
- Helps to grow crops in different climatic conditions.
- Helps to grow high value crops for export market.
- Helps to control pests and diseases.

Availability- Material and services for green houses are commercially available in the market.

Literature for more information:

https://core.ac.uk/download/pdf/82773727.pdf
https://www.ncpahindia.com/green-house
https://www.thebetterindia.com/191511/telangana-startups-greenhouse-in-a-box-saves-water-doubles-farmer-incomes/
https://agritech.tnau.ac.in/horticulture/horti_Greenhouse%20cultivation.html

11. Silage:

Silage is also known as pickle of green fodder and is the conserved green fodder. Silage is the final product when forage of sufficient moisture (> ~50%) is conserved and stored anaerobically (oxygen-free), under conditions that encourage fermentation of sugars to organic acids. The acidity generated by the organic acids (lactic acid, but also acetic and propionic acids) and the lack of oxygen prevent the development of spoilage microorganisms.

Water saving: Fodder is grown in rainy season and preserved in green stage as silage for use in winter and summer season. This way, cultivation of fodder crops in winter and summer season can be avoided which require sufficient irrigation and water may be saved.

Crops suitable for silage making:
The fodder crops, such as maize, sorghum, oats, pearlmillet, and hybrid Napier rich in soluble carbohydrate are most suitable for fodder ensiling.

Advantages:

- ✓ Ensure regular supply of fodder to the dairy animals
- ✓ Silage can be made under almost all-weather conditions
- ✓ Enhances livestock **productivity by ensuring fodder supply, especially during the lean period**

Availability- Silage bags are commercially available in the market

Literature for more information:
https://www.fao.org/3/ca9937en/CA9937EN.pdf
https://www.cornext.in/why-baled-silage/
https://www.nddb.coop/sites/default/files/pdfs/Silage_Making%5B1%5D.pdf

12. Backyard nutrition garden:

Nutrition Garden is significant for ensuring nutritive diet. The garden not only ensures the nutrition of the family but also positively utilises the labour, land and free time of the family as well as improves the financial condition of the family. They can grow different seasonal varieties utilising organic manures and production methods.

The nutrition garden uses the wastewater of the house and other compostable materials to grow vegetables for the needs of the family.

Demonstration of nutrition garden may be established in common places e.g., Anganwadi centres, School & GP premises by diverting the wastewater of these places to kitchen garden.

Advantages:

- ✓ Productive management of the wastewater from each household
- ✓ Reduction in water stagnation & mosquito breeding at villages
- ✓ Production of low cost – nutritive - organic vegetable for each household

Literature for more information:

https://www.leadsindiajh.org/nutrition-garden/#:~:text=The%20nutrition%20garden%20uses%20the,bio%2Daccumulate%20in%20these%20crops.
https://www.orfonline.org/research/nutrition-gardens-a-sustainable-model-for-food-security-and-diversity-67933/
http://icds-wcd.nic.in/nnm/NNM-Web-Contents/LEFT-MENU/Pilots-Innovations/Note-on-Nutrition-Garden-ICAR.pdf
http://www.leafsociety.in/leafs/Waste%20water%20managemnt%20through%20kicthen%20garden.html
https://www.cornellsathgurufoundation.org/blog/csfd-nurtures-kitchen-gardens-through-wastewater-management/

13. Zero/Minimum tillage

Zero tillage is the process where the crop seed will be sown through drillers without prior land preparation and disturbing the soil where previous crop stubble are present.

Zero tillage is also called as no till. Zero tillage is an extreme form of minimum tillage. Primary tillage is completely avoided, and secondary tillage is restricted to seedbed preparation in the row zone only.

It involves considerable soil disturbance, though to a much lesser extent than that associated with conventional tillage. Minimum tillage is aimed at reducing tillage to the minimum necessary for ensuring a good seedbed, rapid germination, a satisfactory stand, and favourable growing conditions.

A. Zero till seed cum fertilizer drill- Seed drill is a device or an agricultural tool that helps in sowing the seeds for a crop by metering or measuring the seeds and placing them in the soil at the appropriate depth and distance.

Zero till seed cum fertilizer drill helps in drilling the seed of a crop fertilizers directly into the cultivated field just after the harvest of the previous crop with the least disturbance of the soil.

B.Super seeder:

Super seeder is tractor mounted machine that cuts and lifts rice straw, sows' wheat into the soil, deposit the straw over the sown area as mulch. **Super Seeder** is an invention for the combined application of soil preparation, seeding with fertilizer and the press wheel. Super Seeder is a combination of Rotary Tiller & Seed Planter.

It also cultivates the paddy straw in the field. This technology is eco-friendly with environment for the health of soil as well as it also saves water.

C.Happy Seeder: A Happy Seeder is a no-till planter, towed behind a tractor, that sows (plants) seeds in rows directly without any prior seedbed preparation. It is operated with the PTO of the tractor and is connected to it with three-point linkage. It consists of a straw managing chopper and a zero till drill that makes it possible to sow new crop in the residue of the previous crop

Water saving: Residual moisture can be effectively utilized, and no. of irrigation can be reduced.

Advantage of zero/Minimum tillage:

- less soil erosion from wind and water (because the mulch cover of previous crops covers the soil)
- less soil compaction
- more fertile and resilient soils

- less moisture evaporation
- lower fuel and labour costs (because there are less passes across the field)

Availability: These farm machines are commercially available in the market.

Literature for more information:

http://www.knowledgebank.irri.org/csisa/images/FactsheetsAndReferences/zero-till%20manual.pdf
https://www.iasabhiyan.com/zero-tillage/
https://www.cgiar.org/innovations/zero-tillage-to-reduce-air-pollution-in-india/
https://justagriculture.in/files/magazine/special/ct/004%20SUPER%20SEEDER.pdf
https://www.cimmyt.org/news/happy-seeder-can-reduce-air-pollution-and-greenhouse-gas-emissions-while-making-profits-for-farmers/

14. Natural farming:

Natural Farming is a chemical-free alias traditional farming method. It is considered as agroecology based diversified farming system which integrates crops, trees, and livestock with functional biodiversity.

It is known by various names like; Zero Budget Natural Farming, Prakrithik Krishi, Cow Based Natural Farming, Shashwat Kheti, Chemical Free Agriculture, etc

Major features of Natural farming are- Soil covering with organic mulch, Use of Bio culture like Jeevamrit & Beejamrit etc., Decomposition of organic matter by microbes and earthworms, Use of natural pesticides like Dashparni ark & Neemastra etc., Multi cropping.

Advantages:

Reduces cost of cultivation: Farmers practising Natural Farming reported similar yields to those following conventional farming. In several cases, higher yields per harvest were also reported

Reduces water requirement of crops-By working with diverse crops that help each other and cover the soil to prevent unnecessary water loss through evaporation, Natural Farming optimizes the amount of 'crop per drop.'

Environment conservation: Natural Farming ensures better soil biology, improved agrobiodiversity, and a more judicious usage of water with much smaller carbon and nitrogen footprints.

Improve yield-Farmers practising Natural Farming reported similar yields to those following conventional farming. In several cases, higher yields per harvest were also reported

Literature for more information

https://ncof.dacnet.nic.in/ConceptNaturalFarming
https://agricoop.nic.in/sites/default/files/PPT%20to%20be%20presentated%20Secretary%20DAFW%20Budget%20Webinar_0.pdf
https://www.niti.gov.in/natural-farming-niti-initiative

15. Value chain interventions

A 'value chain' in agriculture identifies the set of actors and activities that bring a basic agricultural product from production in the field to final consumption, where at each stage value is added to the product. A value chain can be a vertical linking or a network between various independent business organizations and can involve processing, packaging, storage, transport, and distribution.

Location specific water smart crops are being promoted as part of crop diversification initiatives under the Atal Jal scheme. For wider adoption of these crops, proper facilities are required in the area for inputs and services for various pre & post sowing and post harvesting activities as well as for marketing of the produce. Hence, crop specific and area specific interventions may be taken up as per the requirement in the value chain system for promoting these water smart crops.