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https://doi.org/10.47884/jweam.v1i3pp33-44

Journal of Water Engg. and Management

ISSN 2582 6298
Volume-01
Number- 03

Jr. of Water Engg. and Mgt.
2020,1(3) : 34-44

Journal of Water Engg. and Management, 2020, 1(3) : 34-44
https://doi.org/10.47884/jweam.v1i3pp33-44

Research Paper

Hydrological Inferences and Functions of Grasslands : An Indian Scenario

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Received on: 03.10.2020, Accepted on: November 6, 2020

ABSTRACT

Grasslands together with rangelands & pastoral scenery, forms about 40% of the global land surface, and remains an important ecosystem to offer livelihoods for more than 800 million people. They are active sink for about one-third of the global stock of carbon. The growing issues of climate change and water scarcity have added a new dimension to the values of such lands with a critical warning to appropriately understand their hydrological processes and water budget. Harnessing optimum productivity of bio-mass and water from such land parcels is a growing need to cater the upward feeding demands of India's livestock (being largest in the world ~623 M of which at least 50 % depends upon open grazing on natural grasslands). Indian grasslands are still least understood and underestimated natural habitats where grazing-based livestock husbandry continuously influence the regional water economy. The rationale of this paper is revealing potential benefits and developmental prospects of Indian grasslands to facilitate their elementary role to regulate prevailing natural resources at watershed scales. It describes the interacting factors that indeed affect the hydrologic cycle under rangeland/pastureland conditions. The author has shared his own case studies and 20 years operational experiences while being actively engaged in planning, development and management of grasslands, wastelands, and degraded forest catchments in many parts of India. It also includes few outcomes from execution of soil & water conservation plans & measures controlling runoff and soil erosion to deliver better (quantitative & qualitative) biomass outputs from such lands. A substantial food for thought is provided for debating & devising a suitable component of water policy framework exclusively for such lands

Keywords: Grasslands, Livestock, Soil & Water Conservation, Grazing, Hydrology

INTRODUCTION

Grasslands occur in areas where there is not adequate normal rainfall to sustain the escalation of a forest, but also not so modest as to outline a desert. Together with rangelands & pastoral scenery, about 40% of the global land surface is covered by such lands, and it remains an important ecosystem to offer livelihoods for more than 800 million people. These lands are often degraded and are prime source of forage for livestock, wildlife habitat, and other terrestrial ecosystems. Also, they are active sink for about one-third of the global stock of carbon. The growing issues of climate change and water scarcity have added a new dimension to the value of such lands with a critical warning to appropriately understand their hydrological processes and water budget. Harnessing optimum productivity of water as well as bio-mass on such land-parcels is a rising need to cater the upward feeding demands of livestock. Some of the relevant research results reviewed have very well reflected the crucial hydrologic impacts of grazing and range management/improvement practices on soil moisture regime and bio-mass/water productivity on such landscapes.

With the increasing human and livestock population, total demand for food grains may even touch 400 million tons. If we consider only the livestock, their factual water needs are expected to rise up to 2.8 billion m^3 in 2025 and 3.2 billion m^3 in 2050; in contrast to base year 2000 when it were around 2.3 billion m^3. Analogous to this the over-exploitation of ground water resources remains another big concern, as owing to free power supply, over 20 million ground water wells are being pumped excessively, which in turn resulting into a severe depletion in prevailing ground water resources or some time ground water reserves in one region and cheering wastage of ground water in other. Hydrologic regime of Indian grasslands, wastelands and rangelands remains highly sensitive towards specific processes like infiltration and overland flows (Gaur, 2000). Moreover, it offers tremendous opportunities to economically harvest the benefits of rainwater and delivering added benefits not only for surface soils, vegetation but also the vast ground water reserves. A little manipulation in hydrologic elements of grasslands is reported to offer manifold benefits not only in soil moisture storages & added biomass (qualitative as well as quantitative) on grasslands; but being closer to forests, it sizably improves the prevailing forest-water interactions too (Gaur and Gaur, 2019).

Water productivity is being emerged as another sensitive issue, as the existing levels of water use efficiency in Indian agrarian sector, still remains far below from most of the developed countries. The reasons and causes for such inferior water productivity, does not remains only the ineffective irrigation methods (flood irrigation or over-watering), but also the improper water conservation measures and vegetative management in light of higher water demands. Indian farmers & ranchers inevitably require to be further motivated to adopt the concept of conserving agricultural water both rainfall as well as irrigation based supplies. Suitable incentives need to be ensured for farmers who so ever adopts such concepts and takes leads in this crucial aspect. Over 80 million ha of denuded forestlands/wastelands across the country are not in a position or physical state to preserve rainwater, with extended benefits in terms of ensured aquifer recharging, local ground water development, and effective conservation of biodiversity. Comprehensive policy plans in this regard are still to be seen for region specific strains. While water for human utilization is most critical, it is equally imperative for irrigation to enhance food & fodder production via effectual livestock husbandry and thus meeting ever-increasing demands.

It is almost 7 decades since India exits, and many policies and plans for integrated water resource development are chalked, talked and applied, but it is untoward to see the dimension of problem as such. This is truer in case of precise water sector policy & plans specifically for boosting forage, fodder, grasslands, rangelands, forest lands, and all other kind of problem lands. Most of the efforts remained centered towards watershed-based approaches giving full-fledged weightage to arable lands and food grain production followed by cash crops or many other horticultural crops. Even though India happens to be the nation where exists world's highest number of cattle / livestock, water policies and managerial plans keeps human needs at center stage (Gaur and Singh, 1994), at the cost of due share for animals or livestock fraternity.

The motivation of this write-up is enlightening potential benefits and developmental prospects of grasslands to facilitate their straightforward function in amending existing weather or climatic situation, sustaining nutrient cycle & water storage, enabling pollination, upholding biodiversity, enhancing bio-productivity, and averting soil erosion at catchment scales. It describes the interacting factors that indeed affect the hydrologic cycle under rangeland/pastureland conditions. Role of grass & grass like vegetation to influence dominant hydrologic processes (interception, infiltration, soil moisture and runoff) are portrait with research & data-based evidences. Matrix of potential benefits of grasses and grasslands remains a further slice of information accommodating pertinent aspects like rain interception, infiltration dynamics, silt arresting & binding via restraint root systems, soil erosion control, overall runoff regulations, carbon capturing and other emerging ecological issues. The key focus remains more inclined towards customary gaps/ shortcomings of water policies to embark upon the growing opportunities and threat with reference to productive management of grass & forage crops. The author has shared his own case studies and operational experiences while being actively engaged in planning, development and management of grasslands, wastelands, and degraded forest catchments in many parts of India. It also includes few outcomes from execution of soil & water conservation plans & measures controlling runoff and soil erosion to deliver better (quantitative & qualitative) forage biomass outputs from such lands (Gaur and Singh 1994, Gaur, 2006). A substantial food for thought is provided for debating & devising a suitable component of water policy framework exclusively for lands under forage crops, grasses, pastoral systems, forests, and other wastelands; and thus, linking animal sector with soil and water conservation facet.

INDIAN GRASSLANDS

Encompassing merely 2 % of the world's physical area; India supports 20 % of the global farm animals, which include about 16 % of cattle's (cows, bulls, etc.), 55% of the world buffalos, world's second largest goat (20 %) and fourth largest sheep (5 %) populace. For countries like India, the share of forages in cultivated land remained approximately less than 5 % during past many years. In actual facts the grassland area in India uses to be around 80 million ha. In that way, the useful thing/valuable supply from grasslands are all the time quite small. These are further shrinking in terms of their area and productivities because of enormous reasons like heavy grazing pressure even on stripped grazing lands. In an overall picture/situation Indian grazing lands have a grazing pressure of about 3.42 animal grazing units per hectare of grazing land. According to a report by the Forestry Commission, nearly 40% of these protected grassland areas suffer from farm animal's intensive grazing and thus high fodder extractions. Roy and Singh (2013) have well showed that in India, grazing-based farm animals farming plays an important role in overall rural economy, as around 50% of its animals truly depends on grazing. Pastoral lands (a little over 12 Mha) happen to be the major existing grazing resources. Another fact is that, the all existing vegetation on such pastoral lands has no fodder value. Hardly one third Indian grasses are believed to offer due fodder values. Similarly is the situation for vast temperate/alpine pastures which remains spread across elevations higher than 2000 m in the Eastern and Western Himalayas including the Jammu & Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Arunachal Pradesh and Sikkim states. Grazing based livestock production remains a dominant feature on nearly 30 pastoral communities in hilly or dry/semi-dry areas in northern and western parts of India, as well as 20 such species in temperate/hilly regions of country.

Based upon truer on-ground realizations, India has following 5 wider grass covers (Dabadghao and Sankarnarayan, 1973),

1. *Sehima - Dichanthium* grasslands stretching over Deccan plateau, Chota Nagpur plateau and Aravallis (300-1200m above mean sea level i.e. MSL)
2. *Dichanthium-Cenchrus-Lasiurus* grasslands encompassing northern Gujarat, Rajasthan, Aravalli ranges, south-western UP, Delhi and Punjab (150-300m MSL)

3. *Phragmites - Saccharum - Imperata* grasslands covering Gangetic plains, Brahamputra Valley and the plains of Punjab (300-500m MSL)
4. *Themeda-Arundinella* grasslands swelling over the foothills & lower hills of Manipur, Assam, northern West Bengal, Uttarakhand, HP, J&K (350-2000m MSL)
5. *Temperate-Alpine* grasslands- covering Himalayan States as well as temperate high-altitude areas of Nagaland, Manipur & Western Ghats (above 2000 m MSL)

More recently Chandran (2015) tried to expose a concise description of normally found grassland kinds in India as per bio-geographic zones & communities. These were reflected to serve as an updated baseline for researchers engaged in this imperative R&D field. Comprehensive mapping & in-depth understanding of functional architecture of these grasslands is mentioned a crucial need of hour. Six precise grassland labeling namely (1) Coastal Grasslands (mainland beaches, Island beaches, Salt marsh, & mangrove), (2) Riverine Alluvial Grasslands, (3) Montane Grasslands (Himalayan sub-tropical, Himalayan temperate, Alpine meadows, Trans-Himalayan steppes, Grasslands of North East Hills, Grasslands of Central Highlands, Western Ghats including shola grasslands & Montane bamboo brakes), (4) Terai region based Sub-Himalayan Tall grasslands, (5) Tropical Savannas (Desert, Peninsular, Northern hill, closed sal forest grasslands), and (6) Wet grasslands. A more specific spectrum of Montane grasslands of Western Ghats of India was offered by Thomas and Palmer (2007) establishing proven benefits of integrated grassland management on overall ecology as well as conservation of natural resources.

Climate Change Impacts on Grassland

Both at global as well as national level majority of grasslands & rangelands happens to be geographically diverse lands reliant upon existing hydrological regime and foliage management for their distinctiveness, moreover the sustainability of both these key controls is endangered by climate change. Climate change forecast made by IPCC (2014) and others are hardly ever generated exclusively for rangelands. Although not developed for grasslands, IPCC (2014) predictions for climate change until 2100 can be sum up into four foremost drivers of hydrological or vegetative change on these lands: (1) an increase in temperature, most likely upsetting high latitudes more than tropical and subtropical wetlands, reducing snow/ice cover; (2) transformations in total rain or its seasonality patterns; (3) a rise in sea level affecting coastal wetlands; and (4) an increase in climate inconsistency and intense events, notably extreme precipitation and intense temperatures with resultant heat waves, storms, drought, and floods.

Water Use Patterns of Grasslands/Pastoral Systems

Under prevailing circumstances of weather the effective mitigation and adaptation initiatives becomes extremely important and same could be conveniently achieved by caring hydrologic perceptions in an inventive manner like (1) Attempting storage of water at peak rainfall periods to counteract high evaporation rates; (2) Making available lifesaving watering for drought-afflicted sites; (3) Lowering or modifying land/ground surface to facilitate inundation; and (4) Facilitating higher order of soil infiltration and water spreading opportunities. The vast impacts of men, livestock and other managerial elements on water used by vegetation, biomass production (energy) and water use efficiency; can never be shorn of and hence remained the basic causes to regulate the overall water use patterns over grasslands. Researchers have well documented such dominated influences of vegetation types.

Carrying Capability and Production Gaps

Majority of Indian rangelands & grasslands have a low carrying capacity. Accordingly, no part of the country seems to have been secured from a situation of fodder deficit. Say for example in the entire eastern Himalayan region of India, fodder availability is half of the requirement. The natural balance in such rangelands has been greatly upset, with which the 12 million hectares of permanent pastures have been converted into virtual wastelands with pitiable production. The truth remains is that only a little is being done to improve the accessibility of feeding resources for cattle, which in turn highly undermines the remarkable milk production figures of India. There are over one lakh dairy cooperative societies in India with a huge membership of farmers in large numbers (>170) of milk-sheds (areas with intensive dairy operations). However, there exist wide gaps in demand and supply of dry fodder, green fodder, and feed concentrate in varied magnitudes.

INTEGRATED WATER MANAGEMENT ON GRASSLANDS

Meeting Thirst of Dry-lands

Low and uncertain bio-mass yields, thinning profits from the community irrigation arrangements, and micro scale climate change have induced chaotic fluctuations in the hydrologic regimes of dry lands. To ensure the bridging of a large demand-supply gap in fodder remains a big and compelling reason for realizing and harnessing full production potential of grasslands and fodder grown areas. Major cause for low productivities from these vital non-arable lands happens to be the little or no control over the rainfall and also the ensured fitting mechanisms for storing or conserving surplus rain in order to meet the critical water needs during high water stress times for enhancing available moisture for qualitative growth of vegetation thereupon. In India majority of dry lands are in rain-fed province of the country. If we analysis the spectrum of critical rain-fed districts, the dominant rain-fed districts encompass about 27.5 million ha of rain-fed farms and contributes about 85 percent of the rain-fed production at national scale. While offering such giant deliverables, there remains a tremendous scope or potential for utilization of of about 114 billion cubic meter (BCM) of harvestable surplus rainfall. Majority of Indian dry-lands remains thirsty in terms of water and hungry in terms of nutrients. India's per capita reservoir storage is relatively small, and water-use efficiency also remains low (Thatte, 2018), which remains another reason for lower water supplies for dry-lands. Even a tiny fraction of this water when harvested in suitable structures at appropriate location and applied as life-saving supplementary irrigation, have tremendous scope to amply boost the grass/fodder production, and thus setting into shift numerous other multiple effects. The concept of in-situ rain water conservation is well recognized tool and is considered an economically viable approach for optimum utilizations of non-arable kind of land uses specifically the grasslands & pastures.

Water Spreading and Recharging on Grasslands

Whenever we think of developing or managing the water resources on grasslands or rangelands, the foremost strategy remains to enhance the lifesaving soil moisture level in active root zone for prevailing vegetation.

Accordingly, it is the process of infiltration which governs the overall success of vegetative growth. To promote and improve the infiltration opportunities, the concept of water spreading and recharging remains the focal issue while water management of such lands are concerned. There has been plethora of technological options to facilitate such moisture regime buildups. Author has vast practical exposure while implementing variety of soil and moisture conservation measures on degraded grasslands, wastelands and forest lands in an economical way and by utilizing the locally available natural materials.

Improving Groundwater Recharging

Water experts and policy planners (CWC, 2015; GOI, 2016) have already come out with several such schemes where localized efforts for ground water recharging are taken care in a big way. Description of all such efforts and schemes is beyond scope here, because these plans are never ever made specifically for grasslands/rangelands or fodder croplands; rather they remained focused on overall integrated management of water on surface as well as below surface. From the forage crops point of view, one important and innovative effort was the experience of the Dug Well Recharge Scheme

Escalating Water Storage Capacity on Rangelands

It could be surface storage, sub surface storage or even the ground water recharging. In addition to significant ground water recharge, a variety of land and water development actions such as small water pools, water harvesting structures, percolation tanks, reservoirs, small dams could very easily enhance the opportunities for ensuring better soil moisture regime for pastures. Cost effective temporary kind of soil conservation structures/measures are considered a easily adoptable choice where utilizing local mechanical or vegetative materials has been found as of great potential to enhance rainwater conservation and in-situ soil moisture buildup; which indeed increase biomass manifold with least efforts. It also facilitates the environmental demands of controlling soil erosion, soil & water quality enhancements, and various other kinds of on-site/off-site pollutions/pollutants.

Efficient Watering Practices

To face the enormous challenges of water crisis, the efficiency in irrigation is considered most indispensable, as majority of crops are still irrigated by adopting traditional methods & means of irrigation like flood irrigation, where even over 70% of the water supplied remains wasted at the end. Smart irrigation methods (e.g. MIS) and smart water application/allocation ways are the true need of hour. Reducing water conveyance losses is another vital issue in this sector, where utilities of participatory irrigation approaches are getting well recognized even at micro scales and thus helping in improving water use efficiency in cultivated fodder/pastures.

Integrated Watershed Development

Watershed based land and water development has already been established as one of the most successful tool and widely recognized as a measure of overall development in any given basin. As on day over 60% of the cultivated lands in the rain fed areas need to be brought under watershed development to conserve soil and water, which in turn would improve the crop yields as well as ground water table. Prime importance needs to be given for 'grass & pasture development' component in all such watershed-based development efforts.

R & D ON WATER USE IN RANGELANDS/FORAGE CROPS

Plethora of research have been conducted on water use in forage & grasses, and all the time a strong want is felt for spending more on research in relation to water foot prints towards quality grasses and forage productions, ground water measurement & management, water efficient and drought resistant fodder crops, and suitable crop varieties which can cope up with moisture stress as well as the changing climatic conditions, arising due to global warming. Some of the key priority area for action could be,

- Watering options should be well planned by seeking & extending secondary/indirect benefits for non-arable lands too.
- Better promotion of afforestation on riparian lands, degraded forests, wastelands to facilitate soil & moisture conservation, recharging of ground water, preventing of floods and reservoir siltation.
- Improving water conveyance & application efficiencies with sensible water distribution by promoting investment in micro irrigation facilities even on non- arable lands.
- Integrated water resources development on wastelands for preventing soil erosion and run off and improving overall water productivity of these lands.
- Promoting inter-disciplinary researches to learn various vital aspects of land & water resources for protection and sustainable utilization of rangelands and forage crops grown thereupon.
- Seeking innovative & inclusive partnerships in water resources development and conservation

Resiliency & Drought Adaptation on Forests/Rangeland

Adaptations towards moisture deficit & drought like conditions are always considered as an alarming issue, which use to be a vital addressable concern. It must incorporate actively associated elements like region specific characterization of drought, physiological responses of rangelands/forests under such droughts, impacts of drought-like conditions on vegetation dynamics/structure/diversity/management, restoration of native vegetation with relevant adaptations and long-term effects. Droughts are normally recognized as one of four types: (1) meteorological, (2) hydrologic, (3) agricultural, or (4) socioeconomic. Meteorological and hydrologic droughts relate water accessibility to a reference situation (e.g., long-term mean), moreover agricultural and socioeconomic droughts relate to its end impacts. These are the droughts which have great influence and connectivity with grasslands/rangelands based land configurations; offering multiple adverse influences like, higher evaporative demand, the combination of high temperature & low humidity, low soil moisture to induce stress through closure of stomata, carbon stress, loss of hydraulic function, and declined mortality of vegetation/grasses. Compared to agricultural systems, noticing drought impacts on trees & other perpetual flora may require a multi-year “memory” of antecedent surroundings. Lowered water yield from forests & rangelands during extended meteorological drought may produce sizeable impacts on domestic and agricultural water supplies too, which ultimately results in water quantity controls too.

GROUND RESULTS: SUCCESS STORIES & CASE STUDIES

Author himself was actively involved to develop pairs of degraded forests & wasteland catchment for promoting quality grasses, pastures, agro-silvo-pasture, agro-horti-silvi pasture and many other fodder development plans in Jhansi & Datia districts of Bundlkhand part of nation (Gaur, 2000, Gaur and Singh, 1994), by encircling respective catchments of 1381 ha and 500 ha area. Results on variety of soil and moisture development tasks showed highly encouraging outcomes. These low cost soil and water conservation measures comprised (1) about 20 Km long contour furrows (0.8 m^2 section) on 2-4 % slopes at 20 cm VI; 1000 – 1500 running meter per ha pastoral area, (2) Shallow depth staggered pits capable enough to capture 4-5 liters of rainwater at multiple times during intermittent storms to built up soil moisture regime and thus promote better biomass generation ; 17000 pits per ha ; (3) Low height loose boulder dykes of about 7 km length for arresting soil erosion and generating vegetative barriers of soil conservation grasses and thus improving rangelands/forest land surfaces; (4) Staggered contour trenches (0.24 m^2section) capable to arrest 700 to 900 liters of overland flows at multiple times in rainy season , 10000 staggered trenches and about 17 Km continuous trench; (5) Loose boulder check dams to retard channel flow velocities and facilitate ground water recharge and also arresting suspended sediments with ultimate modifications of channel bed profile longitudinal slopes; (6) Micro water harvesting pools and ponds to capture channel flows up to 5 to 40 m3 volumes at a time and thus regenerating natural grasses and vegetation in adjacent areas; (7) Additional surface runoff harvesting potential of about 20000 m^3 i.e. 200 ha-cm was created; and (8) Vegetative barriers made of *vetiver* and *sanchrummunja* grass. These integrated water & land conservation treatments altogether gave a sharp rise in quality and quantity of grass biomass from these treated areas, 6 t/ha dry bio mass in contrast to 1- 2 t/ha at controlled locations. Some of the hydrological indicators (infiltration, silt entrapments in furrows, soil moisture dynamics, peak runoff rates and associated meteorological attributes were assembled by creating an operational real field hydrological experimentation facility. Some of these results are made part of this paper.

Developing Problem Lands/Wastelands

For about 4 million ha of degraded ravenous lands, their scientific reclamation is another big potential area where such fertile lands (mostly located in states of Uttar Pradesh, Madhya Pradesh, Rajasthan & Gujarat), could be profitably utilized for their higher water productivity. It inevitably needs a comprehensive planning in regards to land & water resources for harnessing vast productive potential of these lands via effectual rainwater harvesting. Some of the innovative concepts like using bamboo (truly a grass) for conserving soil and water resources and hydrological improvement of gullies, streams and riparian areas have been proved a boon for Indian ravines (Gaur et al., 2012; Rao et al., 2013; Singh et al., 2014).

Physics of Soil Moisture Dynamics on Rangelands

Spatial and temporal variability of soil moisture varies drastically by direct and indirect factors. Perception in regards to *temporal patchiness happens to be* a sound factor to portray how gradually variations in soil moisture states gave an uncertain state over a given domain of time and space. Both ends of this dynamic spectrum of soil moisture can have substantial impacts on ecological processes and their disorder regimes. For example, high dissimilarity in moisture over relatively short time span can increase the severity of drought-related stressors such as fire or insects. Substantial growth in a forest in a wet year contrasted to dried up conditions in the next year may lead to increased moisture stress because of increased leaf area. While duration is well confined by common drought indices, the high contrast risk is not, and the two are related in almost each climate and soil. While the former is important to critical water supply levels and agricultural crops, the latter has superior context in less synchronized water systems. In absence of direct watering prospect, a variety of moisture conservation measures could be very easily and profitably adopted to enhance or conserve existing soil moisture supplies at majority of pastoral restoration sites. By putting grass seeds at the bottom of furrows, attempting pitting cum discing can very well enhances precipitation capture for better biomass establishment by creating micro-catchments that capture, concentrate, and conserve water over and under the soil surface (Gaur and Singh, 1992).

CONCLUSIONS

Numerous intimidations & pressures are being faced by grassland communities, which remains highly disparaging in tropical regions like India. Primary causes and concerns remain severe anthropogenic pressures, improper land utilizations, excessive grazing pressure, devastating & offensive vegetative species and yes to a big extent the prevailing climate change aspect on such non-arable lands. Several new causes are also evolving to put more intensive burden on Indian grasslands, which comprised recent rapid urbanization, development of tourism amenities in and around natural, especially high altitude, grasslands; which all together have amplified human intrusion and thus deteriorations in extent as well as species of grasses via adverse influences of vast construction material viz., sand transported from other zones. Grasslands are endangered by habitat loss too, which is often caused by human actions, such as unsustainable agricultural practices, overgrazing, and crop clearing. Looking upon Indian conditions the explicit threats to grasslands includes (i) poor agricultural practices which can decay soil & moisture standing of grasslands, (ii) monocropping based agriculture in areas nearing grasslands facilitating profligate depletion of soil's nutrients & moisture, (iii) overgrazing which prevents auto-regeneration of grassland vegetation and also reduces soil infiltration potential due to compaction by cattle movements, (iv) Continued climate change giving lesser & lesser soil moisture regimes, (v) forest & grassland over harvesting making run off and soil erosion very high and intensive , (vi) encroachments of grasslands for agricultural, urban, tourism activities , and (vii) dozens of man-made reasons to overlook the prioritized importance of rainwater harvesting & soil conservation on forest & grasslands which use to be located most often at upstream locations.

Need of the hour is to provide equal importance to grasslands with dedicated package of solutions in terms of (i) location specific land & water management plans (ii) intensive adoption of in-situ moisture conservation technologies, (iii) initiating hydrological R&D on such lands (iv) creating water & soil based data base from normal & depleted grasslands (v) adding values to forage , grasses and other deliverable from grasslands , (vi) adopting controlled or rotational grazing, (vii) initiating smart modeling efforts for integrated land and water management, and (viii) many other location specific innovative interventions to bring harmony on such lands. India happens to be the top ranked nation from milk & dairy based interventions. Grasslands have direct connectivity with livestock and dairy sector, where enhancing water use efficiency and water productivity remains a big opportunity for delivering livestock water-productivity. The reasons for lower water use efficiency does not remains focused on only mis-management of water, but relics equally towards improper land & water conservation measures and also the effectual vegetative management. The truer need of hour is to motivate farmers & ranchers for adopting proven technologies for rainwater harvesting & soil moisture conservation. Policy framework in this regard may incorporates region specific ways and means to motivate small & marginal farmers by facilitating them with incentives as well as availability of low-cost technologies at their door steps. Over 60-80 million ha of denuded forestlands/wastelands across India are unable to properly and amply retain natural rains, which looks to be a big potential to deliver not only the soil-moisture built up & recharging of ground water; but to a big extent a paradigm shift in biodiversity conservation and overall effective management of all natural resources at micro scales. While water for human consumption & agricultural crops is most crucial; it must be considered equally vital for limited irrigation on fodders & grass-based crops too, to augment better fodder production and livestock husbandry for ever-increasing demands. It is almost 7 decades since India exits, and many policies and plans for integrated water resource development are chalked, talked and applied, but it is untoward to see the dimension of problem as such. This is truer in case of precise water sector policy & plans specifically for boosting forage, fodder, grasslands, rangelands, forest lands, and all other kind of problem lands. Most of the efforts remained centered towards watershed-based approaches giving full-fledged weightage to arable lands and food grain production followed by cash crops or many other horticultural crops. Even though India happens to be the nation where exists world's highest number of cattle/ livestock, water policies and managerial plans keeps human needs at center stage (Gaur and Singh 1994), at the cost of due share for animals or livestock fraternity.

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