ഫെബ്രുവരി 2025

അമൃത്
വാർത്താപത്രിക

ലക്കം 12

അമൃത് 2.0 പദ്ധതിയിൽ ഉൾപ്പെടുത്തി ഏലൂർ നഗരസഭയിൽ നവീകരിച്ച നാറാണത്ത് കുളത്തിന്റെ ഉദ്ഘാടനം ബഹു. വ്യവസായ വകുപ്പ് മന്ത്രി ശ്രീ. പി.രാജീവ് നിർവ്വഹിക്കുന്നു

അമൃത് വാർത്താ പത്രിക

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എഡിറ്റോറിയൽ

നഗരങ്ങളിലെ ജലഭദ്രത ലക്ഷ്യമിട്ട് ആരംഭിച്ച അമൃത് 2.0 പദ്ധതി സംസ്ഥാനത്തെ എല്ലാ നഗരസഭകളിലും കാര്യക്ഷമമായി നടന്നുവരികയാണ്. അമൃത് 2.0 പദ്ധതിയോടനുബന്ധിച്ച് നിരവധി പ്രോത്സാഹനാധിഷ്ഠിതമായ പരിഷ്ക്കരണ നടപടികളും അനുബന്ധ പദ്ധതികളും നടപ്പിലാക്കേണ്ടതുണ്ട്. പദ്ധതി നിർവ്വഹണത്തിൽ ജനപങ്കാളിത്തം ഉറപ്പാക്കുന്നതിനും സുതാര്യത ഉറപ്പു വരുത്തുന്നതിനും നടപ്പിലാക്കുന്ന പദ്ധതി ഘടകമാണ് അമൃത് മിത്ര. ഒന്നാംഘട്ടത്തിൽ 31 പദ്ധതികൾക്കാണ് അമൃത് മിത്രയിൽ അംഗീകാരം ലഭിച്ചിട്ടുള്ളത്. പാർക്ക്, കളി സ്ഥലങ്ങൾ എന്നിവയുടെ പരിപാലനം, കുടിവെള്ളത്തിന്റെ ഗുണനിലവാര പരിശോധന, ബില്ലിംഗ്/മീറ്റർ റീഡിംഗ്, വാട്ടർ ചാർജ്ജ്/പ്രോപ്പർട്ടീസ് ടാക്സ് കളക്ഷൻ എന്നീ പദ്ധതികളാണ് ഇതിൽ ഉൾക്കൊള്ളിച്ചിരിക്കുന്നത്. സ്വയം സഹായക സംഘാംഗങ്ങളുടെ ശാക്തീകരണത്തിന് ഉതകുന്ന ഈ പദ്ധതികൾ വളരെ ഗൗരവതരമായി കണക്കിലെടുത്ത് തുടർ നടപടികൾ സ്വീകരിക്കാൻ നഗരസഭകൾ പ്രത്യേക ശ്രദ്ധ പതിപ്പിക്കേണ്ടതുണ്ട്. എൻ.യു.എൽ.എം. (കുടുംബശ്രീ) സഹകരിച്ചാണ് കേരളത്തിൽ പദ്ധതി നടപ്പിലാക്കുന്നത്.

നിലവിൽ അമൃത് പദ്ധതികളുടെ ഫണ്ട് വിതരണം പി.എഫ്. എം.എസ്. എസ്.എൻ.എ. സംവിധാനം വഴിയാണ് കൈകാര്യം ചെയ്യുന്നത്. പുതിയ ഫണ്ട് വിതരണം 'സ്പർശ്' വഴി നടത്തുവാനുള്ള നടപടികൾ നടന്നുവരികയാണ്.

അമൃത് 2.0 യുടെ പരിഷ്ക്കരണ നടപടികളുടെ ഭാഗമായി നടപ്പിലാക്കുന്ന ജി.ഐ.എസ്. അധിഷ്ഠിത മാപ്പിംഗ് എല്ലാ നഗരസഭകളിലും പുരോഗമിക്കുകയാണ്.. 'ജൽ ഹി അമൃത്' രണ്ടാം ഘട്ടം ജലത്തിന്റെ പുനരുപയോഗവും പുന:ചംക്രമണവും ഉറപ്പാക്കേണ്ട പ്രോത്സാഹനാധിഷ്ഠിതമായ പദ്ധതി നിർവ്വഹണം നടന്നുവരികയാണ്. ഇതിലേയ്ക്ക് എല്ലാ നഗരസഭകളുടെയും സഹകരണം പ്രതീക്ഷിക്കുന്നു.

മിഷൻ ഡയറക്ടർ

തദ്ദേശസ്വയംഭരണ വകുപ്പ്
കേരള സർക്കാർ

ചീഫ് എഡിറ്റർ
സൂരജ് ഷാജി ഐ.എ.എസ്സ്
മിഷൻ ഡയറക്ടർ

എഡിറ്റർ
മുരളി കൊച്ചുകൃഷ്ണൻ
എൻവിയോൺമെന്റ് എക്പർട്ട് കം
ഹൈഡ്രോ ജിയോളജിസ്റ്റ്

അസിസ്റ്റന്റ് എഡിറ്റർ
സാവിയോ സജി ഇ.ആർ.

സ്റ്റേറ്റ് മിഷൻ മാനേജ്മെന്റ് യൂണിറ്റ് (അമൃത്)
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തിരുവനന്തപുരം നഗരസഭയിൽ അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി വാങ്ങിയ
സ്പെറ്റേജ് ശേഖരണ വാഹനങ്ങൾ

ആലപ്പുഴ നഗരസഭ, ആലിശ്ശേരി കുളത്തിന്റെ നവീകരണ പ്രവൃത്തികളുടെ ഉദ്ഘാടനം

അമൃത് വാർത്താ പത്രിക

ഫെബ്രുവരി 2025

ഉള്ളടക്കം

5 ജില്ലാതല അവലോകന യോഗം

6 നവീകരിച്ച തച്ചാരുപറമ്പിൽ കുളത്തിന്റെ ഉദ്ഘാടനം

7 നവീകരിച്ച നാറാണത്ത് ക്ഷേത്രക്കുളം ഉദ്ഘാടനം

8 'ഭാരത് ദർശൻ'

9 തൃപ്പക്കുടത്ത് നിർമ്മിക്കുന്ന ജലസംഭരണിയുടെ ശിലാസ്ഥാപനം

10 ഹരിപ്പാട് നഗരസഭയിലെ ബാലമുരുകാ ക്ഷേത്രക്കുളം നവീകരിച്ചു.

11 അമൃത് മിത്ര പദ്ധതിയ്ക്ക് ചാലക്കുടി നഗരസഭയിൽ തുടക്കം

12 ജൽ ഹി അമൃത്.

14 Anaerobic Filters: A Sustainable Alternative to Septic Tanks in Kerala

17 Report on "Land (Soil) and Water Management in India: Natural Pillars of Sustainability"

34 Independent Review and Monitoring Agency (IRMA) Visit

36 TULIP

കൊച്ചി നഗരസഭയിൽ അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി നവീകരിച്ച ടി.പി. കനാൽ

അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി നവീകരണ പ്രവർത്തനങ്ങൾ നടന്നുവരുന്ന അങ്കമാലി നഗരസഭയിലെ ഐക്കാട്ടുകടവ് കുളം

തദ്ദേശ ദിനാഘോഷം 2025 ലോഗോ ബഹു. തദ്ദേശ സ്വയംഭരണ വകുപ്പ് മന്ത്രി പ്രകാശനം ചെയ്യുന്നു

ബഹു. തദ്ദേശ സ്വയംഭരണ വകുപ്പ് മന്ത്രിയുടെ ജില്ലാതല അവലോകന യോഗം

ബഹു. തദ്ദേശ സ്വയംഭരണ വകുപ്പ് മന്ത്രിയുടെ കോഴിക്കോട് ജില്ലാതല അവലോകന യോഗം മുഹമ്മദ് അബ്ദുറഹിമാൻ സ്മാരക ജൂബിലി ഹാളിൽ വച്ച് നടന്നു. മാലിന്യമുക്തം നവകേരളം, ലൈഫ്, അതിദാരിദ്ര്യ നിർമ്മാർജ്ജന പരിപാടി, ഡിജി കേരളം, ജില്ലാതല അദാലത്ത് തീരുമാനങ്ങൾ നടപ്പിലാക്കിയത് എന്നീ അജണ്ടകളാണ് യോഗത്തിനുണ്ടായിരുന്നത്.

കോഴിക്കോട് കോർപ്പറേഷൻ ഡെപ്യൂട്ടി മേയർ, ജില്ലയിലെ തദ്ദേശ സ്ഥാപനങ്ങളിലെ അദ്ധ്യക്ഷൻമാർ, തദ്ദേശ സ്വയംഭരണ വകുപ്പ് പ്രിൻസിപ്പൽ സെക്രട്ടറി ഡോ. ഷർമിള മേരി ജോസഫ് ഐ.എ.എസ്., സ്പെഷ്യൽ സെക്രട്ടറി ശ്രീമതി അനുപമ ടി.വി. ഐ.എ.എസ്., പ്രിൻസിപ്പൽ ഡയറക്ടർ ശ്രീ. സീറാം സാംബശിവറാവു ഐ.എ.എസ്., കോഴിക്കോട് എ.ഡി.എം. ശ്രീ. മുഹമ്മദ് റഫീക്ക്, തദ്ദേശ സ്ഥാപന സെക്രട്ടറി മാർ, ജില്ലാതല ഉദ്യോഗസ്ഥർ എന്നിവരും യോഗത്തിൽ പങ്കെടുത്തു.

അമൃത് 2.0 ൽ ഉൾപ്പെടുത്തി കോഴിക്കോട് വെസ്റ്റ് ഹില്ലിൽ ഒരു എസ്.റ്റി.പി. യ്ക്കായി DBOT model ടെന്റർ നടത്തിയിട്ടുണ്ടെന്ന് കോർപ്പറേഷൻ സെക്രട്ടറി യോഗത്തെ അറിയിച്ചു.

നവീകരിച്ച തച്ചാരുപറമ്പിൽ കുളത്തിന്റെ ഉദ്ഘാടനം ബഹു. റവന്യൂ വകുപ്പ് മന്ത്രി ശ്രീ. കെ. രാജൻ നിർവ്വഹിച്ചു

ഗുരുവായൂർ നഗരസഭയിൽ അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി നവീകരിച്ച തച്ചാരുപറമ്പിൽ കുളത്തിന്റെ ഉദ്ഘാടനം ബഹു. റവന്യൂ വകുപ്പ് മന്ത്രി ശ്രീ. കെ. രാജൻ നിർവ്വഹിച്ചു. 50 ലക്ഷം രൂപ ചെലവിലാണ് കുളം നവീകരിച്ചത്.

കുളത്തിന്റെ നവീകരണ പ്രവൃത്തിയോടൊപ്പം കുളത്തിന്റെ ചുറ്റും നടപ്പാത പണിത് ഹാൻഡ് റെയിലുകൾ സ്ഥാപിച്ചു. കുളത്തിന് പാർശ്വഭിത്തി നിർമ്മിച്ച് ചെളി നീക്കം ചെയ്ത് ആഴം കൂട്ടി ജല ലഭ്യതയും സംഭരണ ശേഷിയും വർദ്ധിപ്പിച്ചു. കൂടാതെ പരിസരം വൃത്തിയാക്കി ചുറ്റുമതിൽ സ്ഥാപിച്ച് ഇരിപ്പിടങ്ങൾ ഒരുക്കി. നടപ്പാത ടൈലുകൾ പാകി മനോഹരമാക്കി. വ്യായാമത്തിനായുള്ള ജിം ഉപകരണങ്ങൾ സ്ഥാപിച്ച് ജനങ്ങൾക്ക് വ്യായാമത്തിനുള്ള സൗകര്യമൊരുക്കി. വൈദ്യുതി വിളക്കുകൾ സ്ഥാപിച്ച് കുളത്തിന്റെ രാത്രി കാഴ്ചയും മനോഹരമാക്കി.

കുളം നവീകരിച്ചതോടെ പരിസര വാസികൾക്ക് വിനോദത്തിനും വ്യായാമത്തിനും ഉള്ള അവസരം സൃഷ്ടിക്കാൻ സാധിച്ചു. കൂടാതെ പരിസരത്തെ ഭൂഗർഭ ജലലഭ്യത വർദ്ധിപ്പിക്കുന്നതിനും കുളത്തിന്റെ നവീകരണം സഹായിച്ചിട്ടുണ്ട്.

നവീകരിച്ച നാറാണത്ത് ക്ഷേത്രക്കുളം ബഹു. വ്യവസായ വകുപ്പ് മന്ത്രി ശ്രീ. പി.രാജീവ് ഉദ്ഘാടനം ചെയ്തു

അമൃത് 2.0 പദ്ധതിയിൽ ഉൾപ്പെടുത്തി ഏലൂർ നഗരസഭയിൽ നവീകരിച്ച നാറാണത്ത് ക്ഷേത്രക്കുളം ബഹു. വ്യവസായ വകുപ്പ് മന്ത്രി ശ്രീ. പി.രാജീവ് ഉദ്ഘാടനം ചെയ്തു.

100 വർഷത്തോളം പഴക്കമുള്ള ക്ഷേത്രക്കുളമാണ് നവീകരിച്ചത്. 30 മീറ്റർ വീതിയും 30 മീറ്റർ നീളവുമുള്ള കുളത്തിന്റെ ചെളി കോരി വെള്ളം ശുചീകരിച്ച് പടവുകൾ കെട്ടിയായിരുന്നു നവീകരണം. ചുറ്റും കൈവരിയും നടപ്പാതയും കെട്ടി ആകർഷകമാക്കി. 28 ലക്ഷം രൂപ ചെലവിലാണ് നവീകരണ പ്രവൃത്തികൾ പൂർത്തീകരിച്ചത്. അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി ഏലൂർ നഗരസഭയിൽ മൂന്ന് കുളങ്ങളാണ് നവീകരിക്കുന്നത്. ഇതിൽ പാട്ടുപുരയ്ക്കൽ കുളം ഇതിനോടകം തന്നെ നവീകരിച്ചു കഴിഞ്ഞു.

'ഭാരത് ദർശൻ' പരിപാടിയുടെ ഭാഗമായി 17 ഐ.എ.എസ്. ട്രെയിനികൾ തിരുവനന്തപുരം കോർപ്പറേഷനും മാലിന്യ സംസ്കരണ കേന്ദ്രങ്ങളും സന്ദർശിച്ചു

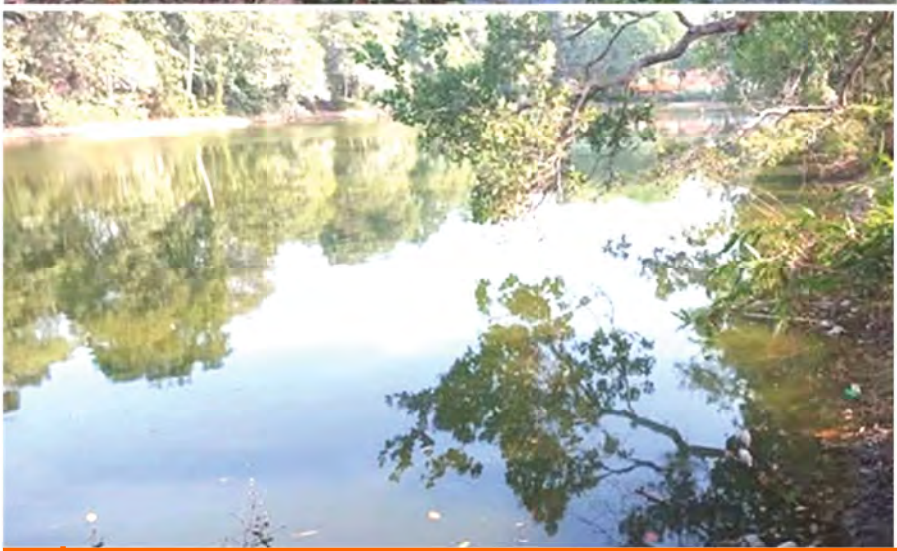
തൃപ്പക്കുടത്ത് ജലസംഭരണിയുടെ ശിലാസ്ഥാപനം ബഹു. എം.എൽ.എ. ശ്രീ. രമേശ് ചെന്നിത്തല നിർവ്വഹിച്ചു

അമൃത് 2.0 പദ്ധതിയിൽ ഉൾപ്പെടുത്തി ഹരിപ്പാട് നഗരസഭയിലെ തൃപ്പക്കുടത്ത് നിർമ്മിക്കുന്ന ഏഴുലക്ഷം ലിറ്റർ സംഭരണ ശേഷിയുള്ള ജലസംഭരണിയുടെ ശിലാസ്ഥാപനം ബഹു. എം.എൽ.എ. ശ്രീ. രമേശ് ചെന്നിത്തല നിർവ്വഹിച്ചു.

4.28 കോടി രൂപയാണ് ജലസംഭരണിക്ക് വിനിയോഗിക്കുന്നത്. അനുബന്ധമായുള്ള ജലവിതരണ ശൃംഖല സ്ഥാപിക്കുന്നതിന് 68.5 ലക്ഷം രൂപ വിനിയോഗിക്കും. 4.965 കോടി രൂപയാണ് പദ്ധതിയുടെ ആകെ ചെലവ്.

തൃപ്പക്കുടത്ത് നഗരസഭയുടെ കളിസ്ഥലത്തിന്റെ ഒരു ഭാഗത്താണ് ജലസംഭരണി നിർമിക്കുന്നത്. പള്ളിപ്പാട്ട് നിർമാണം പുരോഗമിക്കുന്ന ഹരിപ്പാട് കുടിവെള്ള പദ്ധതിയുമായി കൂട്ടിയിണക്കിയാണ് തൃപ്പക്കുടത്തെ ജല വിതരണ പദ്ധതിയുടെ പ്രവർത്തനം വിഭാവനം ചെയ്തിരിക്കുന്നത്.

ഹരിപ്പാട് നഗരസഭ ബാലമുരുകാ ക്ഷേത്രക്കുളം നവീകരിച്ചു



അമൃത് 2.0 പദ്ധതിയിലെ ജലാശയങ്ങളുടെ നവീകരണം എന്ന സെക്ടറിൽ ഉൾപ്പെടുത്തി ഹരിപ്പാട് നഗരസഭയിലെ ബാലമുരുകാ ക്ഷേത്രക്കുളം നവീകരിച്ചു.

ക്ഷേത്ര നഗരി എന്ന് വിശേഷിപ്പിക്കപ്പെടുന്ന ഹരിപ്പാട് നഗരസഭയിലെ പുരാതനമായ മണി മംഗലം ക്ഷേത്രത്തോട് ചേർന്ന് സ്ഥിതി ചെയ്യുന്ന രണ്ട് ഏക്കറിൽ കൂടുതൽ വ്യാപിച്ച് കിടക്കുന്ന ക്ഷേത്രക്കുളമാണ് ബാലമുരുകാ ക്ഷേത്രക്കുളം. ഭൂഗർഭ ജലസ്രോതസ്സ് നിലനിർത്തുന്നതിൽ വളരെയധികം പ്രാധാന്യമുണ്ട്.

ഹരിപ്പാട് നഗരസഭ അമൃത് പദ്ധതിയിൽ ഉൾപ്പെടുത്തി 80 ലക്ഷം രൂപയുടെ നവീകരണ പ്രവർത്തികൾ ബാലമുരുകാ ക്ഷേത്രക്കുളത്തിൽ നടത്തിയിട്ടുണ്ട്. കുളത്തിൽ കാലങ്ങളായി അടിഞ്ഞുകൂടിയ ചെളിയും മറ്റ് അവശിഷ്ടങ്ങളും നീക്കം ചെയ്യുകയും കുളത്തിന്റെ സംരക്ഷണ ഭിത്തി നിർമ്മിക്കുകയും ചെയ്തു. ഇതിനാൽ കൂടുതൽ ജലം സംഭരിക്കുന്നതിനും മാലിന്യം നിർമ്മാർജ്ജനം ചെയ്യുന്നതിനും കഴിഞ്ഞിട്ടുണ്ട്.

ചാലക്കുടി നഗരസഭയിൽ അമൃത് മിത്ര പദ്ധതി ഉദ്ഘാടനം ചെയ്തു

അമൃത് 2.0 യുടെ ഭാഗമായി നടപ്പിലാക്കുന്ന അമൃത് മിത്ര പദ്ധതിയ്ക്ക് ചാലക്കുടി നഗരസഭയിൽ തുടക്കം കുറിച്ചു. കുടുംബശ്രീയുമായി സഹകരിച്ചാണ് പദ്ധതി നടപ്പിലാക്കുന്നത്. തിരഞ്ഞെടുത്ത കുടുംബശ്രീ അംഗങ്ങൾക്ക് അടുത്ത ഒരു വർഷത്തേയ്ക്ക് തൊഴിൽ നൽകുന്ന ഈ പദ്ധതിയിൽ നഗരസഭയിലെ കലാഭവൻ മണി പാർക്ക്, പൗലോസ് താക്കോൽക്കാരൻ പാർക്ക് എന്നിവയുടെ സൗന്ദര്യവത്ക്കരണവും പരിപാലനവുമാണ് ആദ്യ ഘട്ടത്തിൽ നടപ്പിലാക്കുന്നത്.

അമൃത് 2.0 യിൽ ഉൾപ്പെടുത്തി 16 കോടി രൂപയുടെ ശുദ്ധജല പദ്ധതിയുടെ പ്രവർത്തനങ്ങൾ നഗരസഭയിൽ പുരോഗമിക്കുകയാണ്. ഹൈ ലെവൽ, ലോ ലെവൽ പദ്ധതികളുടെ നവീകരണവും 2500 വീടുകളിലേയ്ക്കുള്ള സൗജന്യ ശുദ്ധജല കണക്ഷനും പദ്ധതിയിൽ ഉൾപ്പെടും.

നഗരസഭയിലെ 7 പൊതുകുളങ്ങൾ നവീകരിക്കുന്നതിന് 1.40 കോടി രൂപയുടെ പദ്ധതിയ്ക്ക് അംഗീകാരം ലഭിച്ചിട്ടുണ്ട്. അമൃത് മിത്ര പദ്ധതി നടപ്പിലാക്കുന്നതിന് ഒരു വർഷത്തേയ്ക്ക് 10 ലക്ഷം രൂപയാണ് അനുവദിച്ചിരിക്കുന്നത്. അമൃത് മിത്ര പദ്ധതിയുടെ ഉദ്ഘാടനം നഗരസഭ കലാഭവൻ മണി പാർക്കിൽ നഗരസഭാ ചെയർപേഴ്സൺ ഇൻ ചാർജ്ജ് ആലീസ് ഷിബു നിർവ്വഹിച്ചു.

ജൽ ഹി അമൃത്

കേന്ദ്ര ഭവന നഗരകാര്യ വകുപ്പ് ജലത്തിന്റെ പുന:ചംക്രമണവും ദ്രവ മാലിന്യ സംസ്കരണ പ്ലാന്റിൽ നിന്ന് സംസ്കരിച്ച ജലത്തിന്റെ ഗുണനിലവാരം മെച്ചപ്പെടുത്തുന്നതിനുമായി ആരംഭിച്ച പ്രോത്സാഹനാധിഷ്ഠിതമായ ഉദ്യമമാണ് ജൽ ഹി അമൃത്. പദ്ധതി നടപ്പിലാക്കുന്ന നഗരസഭകളെ വിവിധ ഗ്രൂപ്പുകളായി തിരിച്ച് സ്റ്റാർ റേറ്റിംഗ് നടത്തി പ്രോത്സാഹന തുക നൽകുന്നു.

Star Rating	Group - I	Group - II	Group - III	Group - IV	Group – V
	STPs with Treatment Capacity (in MLD)				
	< 5	5 to 10	10 to 50	50 to 100	> 100
*****	0.75 Cr.	1.5 Cr.	4 Cr.	6 Cr.	8 Cr.
****	0.5 Cr.	1 Cr.	2 Cr.	3 Cr.	5 Cr.
***	0.25 Cr.	0.75 Cr.	1 Cr.	2 Cr.	3 Cr.

- **STPs with rating 3 Star & above** will be eligible for incentive.
- **70:30 incentive release structure** is proposed.
- **Upfront 70%,** after rigorous evaluation and capacity building.
- **Remaining 30%,** after successful maintaining of star rating for next 6 months.
- 4 Star & 3 Star-rated STPs will also be eligible for balance incentive
  - Upon upgradation of their Standards to 5 Star & 4 Star rating respectively by next year
  - Balance incentive will be given as earmarked for higher rating.

Conditions for Fund Release

Setting-up Water Resource Recovery Cell (WRRC) at State level

- Cell comprising of government representatives to oversee STPs, expedite their implementation, and operate them
  - Urban Development
  - Irrigation/ Agriculture
  - Power
  - Public Health
  - Industrial
  - State Pollution Control Board
  - ULBs officers
- **Creation of Escrow Account**

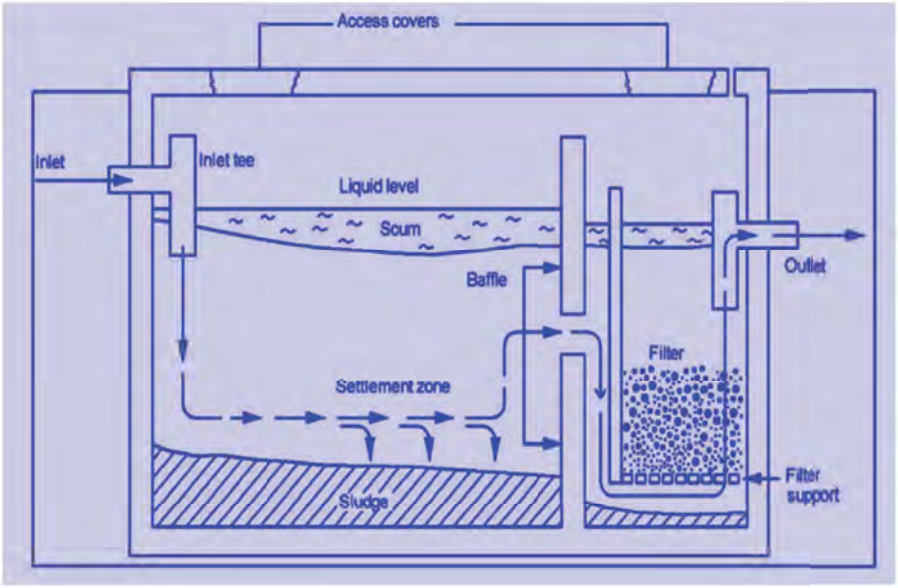
Utilization of Incentives

- Operational efficiency improvement measures
- Technology upgradation
- Capital expenditures for reuse infrastructure
- Setting up of Real Time Data Management System like OCEMS, SCADA
- Capacity Building of Staff
- Setting up of new & renewable energy for running STPs
- Management of biosolids

Anaerobic Filters: A Sustainable Alternative to Septic Tanks in Kerala

Introduction

Anaerobic filters, also known as fixed bed or fixed film reactors, are advanced wastewater treatment systems that present distinct advantages over conventional septic tanks. In Kerala, where poorly constructed septic tanks significantly contribute to environmental degradation, anaerobic filters emerge as a practical and efficient alternative for treating both domestic and industrial wastewater.



Simple one unit anaerobic Filter integrated in the second chamber of a septic tank

VIJAYAKUMAR M.K.
Urban Infrastructure cum Water Expert
State Mission Management Unit, AMRUT

Operating Principles

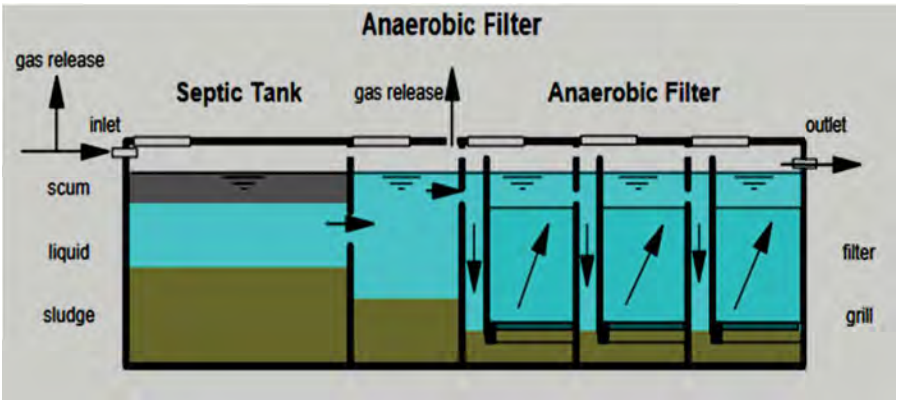
Anaerobic filters operate on the principles of sedimentation and sludge digestion, akin to septic tanks, but extend their functionality to treat non-settleable and dissolved solids. These systems promote the close interaction of organic matter with an abundant population of active bacteria. The largely immobile bacteria form a “lawn” or “film” on reactor walls or filter media, enabling effective organic matter digestion within short retention times. This mechanism makes anaerobic filters significantly more efficient than traditional septic tanks.

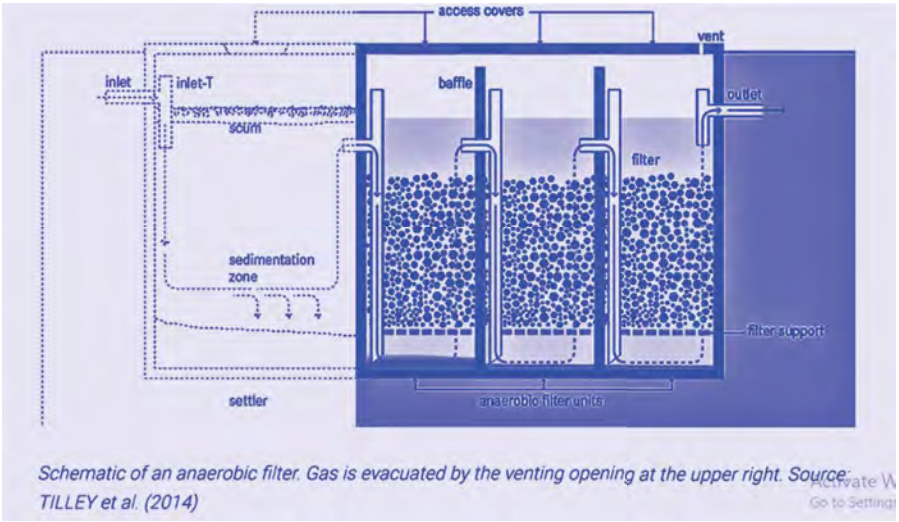
Design and Functionality

The efficiency of anaerobic filters lies in their filter media, which provide extensive surfaces for bacterial colonization. Commonly used materials include gravel, boulders, cinder, pumice, and specially designed plastic components, offering surface areas ranging from 90 to 300 m^2 per cubic meter of reactor volume. Rough surfaces on filter media enhance bacterial adhesion, boosting performance, especially during initial stages.

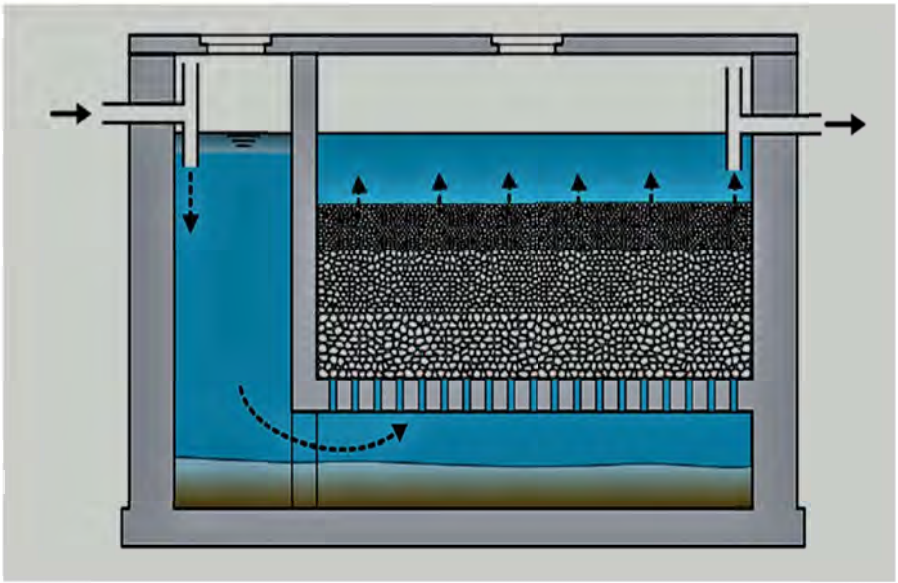
System Design Features:

- **Capacity:** 0.04 to 0.05 m^3 per capita, or approximately one-third to half the liquid capacity of a comparable septic tank. The typical sizes of filter materials range from 12 to 55 mm in diameter, gradually decreasing from the bottom to the top. Commonly used materials include gravel, crushed rocks, bricks, cinder, pumice, or specially designed plastic pieces, depending on local availability. It is recommended to use filters with two to three layers and a minimum depth of 0.8 to 1.2 meters. The chambers can be connected using either vertical pipes or baffles. Access ports should be provided for all chambers to ensure easy maintenance. Additionally, the tank must be vented to allow the safe release of odorous and potentially harmful gases.
- **Flow Configurations:** Systems can be constructed as up-flow or down-flow designs. The up-flow configuration minimizes the risk of bacterial washout, while down-flow designs simplify cleaning.
- **Wastewater Distribution:** Equal distribution across the filter surface is crucial for optimal performance.
- **Additional Components:** Many systems integrate sedimentation chambers to remove solids and garbage, preventing clogging and enhancing filter performance.





Schematic of an anaerobic filter. Gas is evacuated by the venting opening at the upper right. Source: TILLEY et al. (2014)



Close-up schematic cross-section of an anaerobic filter, showing filling material with a decreasing diameter from bottom to top.

Advantages Compared to Septic Tanks

1. **Higher Efficiency**: In well-operated anaerobic filters, the treatment efficiency has been reported to achieve 50 to 90% removal of Biochemical Oxygen Demand (BOD), depending on the quality of the influent .Total Suspended Solids (TSS) removal ranges from 50 to 80%, while total nitrogen removal can reach up to 15%. Total coliform reduction is typically around 90%.

2. The recommended hydraulic retention time (HRT) varies based on the type of wastewater. For pre-settled blackwater, the HRT should range between 1.5 to 2 days whereas for grey water, an HRT of 0.7 to 1.5 days is sufficient.
3. **Space Efficiency:** Compact designs require a gross digester volume of approximately 0.5 m^3 per person, making them ideal for densely populated areas.
4. **Reduced Environmental Impact:** Pre-treatment minimizes the release of suspended solids and other pollutants into waterbodies.
5. **Versatility:** Suitable for treating domestic and industrial wastewater with low suspended solids.
6. **Ease of Maintenance:** Routine cleaning, back-flushing, and desludging ensure sustained efficiency.

Maintenance and Operational Guidelines

To achieve optimal performance:

- **Start-up Phase:** Apply active sludge from septic tanks to the filter media. Gradually increase flow rates over three months to stabilize bacterial colonies. Full efficiency is typically achieved within six to nine months.
- **Routine Maintenance:** Regular desludging and periodic back-flushing prevent clogging and ensure uniform retention times.

Preventive Measures: Employ coarser filter media at the bottom and ensure even wastewater distribution to minimize clogging and channeling.

Challenges and Solutions

Clogging: A common issue when smaller pore sizes are used.

- Solutions include:

Using coarser filter media in lower sections.

- Ensuring primary sedimentation to remove settleable solids.
- Regular maintenance to prevent blockages and maintain efficiency.

Odour Management: Tanks should be vented to safely release odorous and potentially harmful gases.

Applicability in Kerala

Kerala faces significant challenges from unscientifically constructed septic tanks, leading to high levels of coliform bacteria in waterbodies and shallow groundwater aquifiers. Anaerobic filters provide a robust solution by offering superior treatment efficiency and minimizing environmental pollution. Their compact design and underground installation make them particularly suitable for Kerala's densely populated regions.

This technology can be implemented at various scales:

- **Household Level:** Stand-alone units for small-scale wastewater management.
- **Community Level:** Systems integrated with anaerobic baffled reactors (ABRs) for semi-centralized treatment.

Large-Scale Applications: In combination with other technologies for industrial and municipal wastewater management.

Conclusion

Anaerobic filters present a sustainable and effective alternative to conventional septic tanks, addressing many inefficiencies and environmental concerns in Kerala's wastewater management systems. By adopting this technology, Kerala can significantly improve water quality, safeguard public health, and reduce the ecological impact of wastewater discharge. With proper design, implementation, and maintenance, anaerobic filters can play a pivotal role in building a cleaner and healthier Kerala.

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Report on "Land (Soil) and Water Management in India: Natural Pillars of Sustainability"

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Introduction:

Soil and water are indispensable for the existence and survival of all terrestrial life. These are the basic resources to the requirement for food, feed, fuel, and fiber of human beings. Soil and water are the most important natural resources that meet all human and animal needs, and protect the environment and the civilization aspects. Ever increasing demands for land and water resources due to burgeoning unprecedented population raise causes the degradation of these two precious natural resources viz land and water. Land degradation is a serious problem in India and out of 329 million hectares (Mha) of total geographical area, **146.8 Mha is reported as degraded**. India is losing a huge amount of money in terms of loss of productivity from these degraded lands. Though India receives good amount of annual rainfall (1190 mm), due to enhanced need for domestic, agriculture and industrial developmental activities, over-exploitation and laxity of water resource, it becomes scarce. The declining trend of groundwater level in all parts of the country also indicates that the assured supply of good quality water has become a concern for country's development. Hence holistic and integrated management approaches of soil and water resources by linking social and economic development with protection of natural ecosystem is the need of the hour. Creation of inventory on soil and water resources, use of modern technological tools for developing conservation strategies, changes in policy to protect natural resources, development of site-specific soil and water conservation measures and involvement of local people in conserving the soil and water resources are the future challenges in line with respect to land and water resource Development.

Over view of Land Resources in India.

In India, high percentage of area under degraded land are in Jammu and Kashmir (69.24%), Himachal Pradesh (50.90%) is due to snow cover and degraded forest; Nagaland (22.37%), Manipur (59.01%), Mizoram (21.20%) is due to shifting cultivation, Sikkim (53.67%) is due to degraded forest and in Rajasthan (29.64%) is due to sandy area. The category-wise distribution of wastelands shows that highest percentage (4.76%) belongs to the category 'land with scrub' mainly distributed in the southern states of India followed by 'underutilized forestland' (3.42%) distributed throughout the country. Among the 583 districts, 19 districts mainly distributed in NE states, Jammu Kashmir and Rajasthan have got more that 50% of geographical area under wastelands (MoRD & NRSA,).

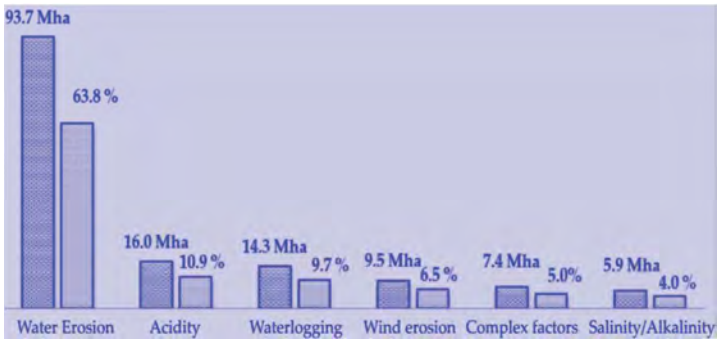

Fig: 1. Contribution of land degradation factors in India, (Source: NBSS & LUP)

According to the National Bureau of Soil Survey and Land Use Planning, **146.8Mha land is degraded in India.** Water and wind erosion are the most serious degradation problem in India, resulting in loss of topsoil and terrain deformation followed by acidity and water logging.

Based on first approximation analysis of existing soil loss data, the average soil erosion rate was **16.4 ton/ha/year resulting in an annual total soil loss of 5.3 billion tons throughout the country**. **Nearly 29% of total eroded soil is permanently lost to the sea, while 61% is simply transferred from one place to another and the remaining 10% is deposited in reservoirs.**

Overview of Water Resources in India.

Surface Water:

India has a large and intricate network of river systems of which the most prominent are the Himalayan River systems draining the major plains of the country. Apart from this, numerous water bodies present in the subcontinent make it one of the wettest places in the world after South America. The annual precipitation including snowfall, which is the main source of the water in the country, is estimated to be 4000 billion cubic meters (BCM). Central Water Commission estimated the basin wise resource potential of the country, which occurs as natural runoff in the rivers is about 1869 cu.km. Ganga-Brahmaputra-Meghna system is the major contributor to total water resources potential of the country with about 60% of the share in total water resources potential of the various rivers. In majority of river basins, present utilization is significantly high and is in the range of 50–95% of utilizable surface resources except the rivers such as Narmada and Mahanadi where the utilization is quite low.

Groundwater:

Groundwater resources consist of two parts, namely, dynamic and static, the dynamic resource present in the zone of water table fluctuation, whereas the static resource will be below the dynamic zone which remains perennially saturated. As per the National Water Policy, the dynamic groundwater resource is essentially the exploitable quantity of groundwater, which is recharged annually, and is also termed as replenishable groundwater resource.

India is one of the largest users of ground water in various sectors like agriculture, domestic and industrial. Potential use of Ground water irrigation has been increased at a very rapid pace since 1970s. Ground water sustainability and its availability play a vital role in ensuring livelihood as well as food security across the country, especially in (UP, Panjab, Haryana, WB, etc.) where economies depend on agriculture. Rural agriculture and drinking water sector are dependent partly or wholly on groundwater through pumping and/or spring or river due to facile access. However, urban populations highly rely on groundwater due to unreliable and deficient quality of water supplies from other sources. Unplanned Intensive irrigation, domestic and industrial use of Groundwater created serious problems for scientific community in planning management of groundwater. Saltwater encroachment near coast, depletion in water tables, water logging, drying of aquifers, pollution of groundwater, and salinity, etc. are major consequences of overexploitation. Deterioration in groundwater quality by various causes is another serious issue. Despite the cumulative effort of different stakeholders, 20% of groundwater blocks are semi-critical, critical, or overexploited. Moreover, aquifers depletion in the most populated and economically productive areas of the country encourages us to understand and create an overall scenario of Indian aquifer system.

As per the 2022 assessment of India's dynamic ground water resources, which was conducted jointly by the Central Ground Water Board (CGWB) and state ground water departments. The total annual ground water recharge for India is estimated at 437.60 billion cubic meters (bcm). The main source is monsoon rainfall at 241.35 bcm, comprising 55% of total recharge. The total annual extractable ground water resource is 398.08 bcm. Of this, 239.16 bcm is currently extracted annually, with 87% (208.49 bcm) used for irrigation.

1.	TotalAnnualGroundWaterRecharge	437.60 bcm
2.	Annual Extractable Ground Water Resources	398.08 bcm
3.	Annual Ground Water Extraction	239.16 bcm
4.	Stage of Ground Water Extraction	60.08 %

Table: 1, Ground Water Resources Scenario. Source CGWB

Based on the stage of extraction, assessment units across states/UTs are categorized as safe (67%), semi-critical (12%), critical (4%) or over-exploited (14%). In terms of assessment units, the stage of ground water extraction is highest in Haryana, Punjab, Rajasthan, Dadra & Nagar Haveli and Daman & Diu, where extraction exceeds 100% of extractable resources. Compared to the 2020 assessment, total annual recharge has increased slightly by 1.45 bcm and extractable resources by 0.46 bcm. Ground water extraction has marginally reduced from 244.92 bcm to 239.16 bcm.

Sl.No	Category	Number of Assessment Units		Recharge worthy Area		Annual Extractable Ground Water Resource	
		Number	%	inlakh sq.km	%	(inbcm)	%
1	Safe	4780	67	16.18	66	291.88	73
2	SemiCritical	885	12	3.03	12	47	12
3	Critical	260	4	0.77	3	13.02	3
4	Over-Exploited	1006	14	4.30	17	46.05	12
5	Saline	158	2	0.4	2	NA	NA
	TOTAL	7089		24.69		398.08	

Tab: 2- Categorization of Assessment Units as per GWRA-2022, Source CGWB

Fig 1.A Water Conservation Measures

As per Dynamic Ground Water Resource Estimation of the Country as on 2022, the total annual ground water recharge has been assessed as **437.60 bcm.** Keeping an allocation for natural discharge, the annual extractable ground water resource works out as **398.08 bcm**. The total annual ground water extraction (as in 2022) has been assessed as **239.16 bcm**. The average stage of ground water extraction for the country as a whole works out to be about **60.08 %.** The extraction of ground water for various uses in different parts of the country is not uniform. Out of the **total 7089 assessment units (Blocks/ Districts/ Mandals/ Talukas/Firkas) in the country 1006 units in various States (14 %) have been categorized as 'Over-Exploited'** indicating ground water extraction exceeding the annually replenishable ground water recharge. **A total of 260 (4 %) assessment units have been categorized as 'Critical'**, where the stage of ground water extraction is between 90-100 % of annual extractable resources available. **There are 885 'Semi-Critical' units (12 %),** where the stage of ground water extraction is between 70 % and 90% and **4780 (67 %) assessment units have been categorized as 'Safe' where the stage of Ground water extraction is less than 70 %.** Apart from this, there are 158 assessment **units (2 %), which have been categorized as 'Saline'** as major part of the ground water in phreatic aquifers is brackish or saline. Similarly out of 24.69 lakh sq km recharge worthy area of the country, 4.30 lakh sq km (17 %) are under 'Over- 1 3 | P a g e Exploited', 0.77 lakh sq km (3 %) are under 'Critical', 3.03 lakh sq km (12 %) are under 'Semi-Critical', 16.18 lakh sq km (66 %) are under 'Safe' and 0.4 lakh sq km (2 %) are under 'Saline' category assessment units. Out of 398.08 bcm of Total Annual Extractable Resources of the country, **46.05 bcm (12 %) are under 'Over-Exploited', 13.02 bcm (3 %) are under 'Critical', 47 bcm (12 %) are under 'Semi-Critical', 291.88 bcm (73 %) are under 'Safe' category assessment units.**

Soil and Water Conservation Strategies in India.

In India, the soil and water conservation strategies are to be an inbuilt processes of integrated watershed development. it is not only important to increase the availability of water but also efficient utilization of water should be promoted by adopting other techniques like multiple use of water, proper soil and crop management, low-cost micro irrigation, integrated farming system, etc. Adaptation of suitable soil and water conservation measures and cultivating crops based on land suitability is the first and most important factor which can reduce the soil degradation problems. Micro scale rain water harvesting from the farm lands and multiple uses in the farmers field itself is the right approach for increasing the water productivity and livelihood security of rural farmers.

Broader Issues and Problems towards Land (soil) and water resources management in a micro watershed level:

- Changes in land use and faulty management practices accelerated soil erosion and have led to irrevocable land degradation,
- Soil erosion is one of the serious problems which not only impair the quality of land and water resources but also harm agricultural production and the socio-economic condition of farmers.

Fig 1.B Impacts of Soil Erosion

- Among various land degradation processes, water erosion is a major problem affecting 68.4% of the total land area in India in India, various organizations have estimated the extent of land degradation NBSS and LUP has been reported about 146.8 mha degraded land area in India
- Water erosion, Wind erosion (Eolian), Chemical degradation, exclusively like salt-affected soils, soils Acidic and water eroded soils, mining and industrial waste, Permanent Water logging etc are some of the land related problems in a watershed.

Soil Erosion and Erosion causing agents:

Soil erosion is the removal of topsoil by the physical forces of erosion causing agents at a greater rate than the rate of its formation. Initially, erosion removes the nutrient-rich fertile top layer of soil which leads to the reduced production potential of soil. **Soil erosion is classified into two categories, i.e., accelerated and geological erosion. Geological erosion is the natural phenomenon, occurs through the constant process of weathering and disintegration of rocks in which the rate of erosion remains lower than the soil formation rate**. In contrast, in accelerated erosion, the rate of soil erosion exceeds a certain threshold level and becomes rapid. Anthropogenic activities such as slash-and-burn agriculture, overgrazing, deforestation, mining, and intensive and faulty agriculture practices are accountable for accelerated soil erosion. This higher rate of soil erosion leads to the removal of organic matter and plant nutrients from the fertile topsoil and eventually lowering crop productivity. Hence, the conservation and management of natural resources are essential. Although the soil erosion cannot be eliminated, however it must be reduced to the level that can minimize its adverse impact on productivity and agricultural sustainability.

Water and wind are two key agents that degrade soils through various kinds of erosion processes. Runoff removes the soil particles from sloping and bare lands while the wind blows away loose and detached soil particles from unprotected lands. Other processes of land degradation are soil compaction, waterlogging, acidification, alkalinization, and salinization depends on parent material, climatic conditions, and crop management practices. In this chapter, we will discuss about the soil erosion by water, different types, processes, factors, and management.

Water Erosion:

Water erosion is the most severe type of soil erosion. In this form of erosion, detachment, and transportation of soil particles from their parental source take place by water through the action of rainfall, runoff, hailstorm, and irrigation. Water erosion is a prevailing form of erosion in humid and sub-humid agro-ecosystems. It also creates the problem in arid and semiarid regions, characterized by an intensive rainstorm and scanty vegetation cover. Water erosion comprises three basic phases, i.e., detachment, transportation, and deposition. Rainfall is one of the major factors which causes the movement and detachment of soil particles. The detached soil particles seal the open-ended and water-conducting soil pores, reduce water infiltration, and cause runoff. The first two phases determine the quantity of soil to be eroded and the third phase determines the distribution of the eroded material along the landscape. If there is no dispersion and transport of soil particles, there will be no deposition. Hence, detachment and transport of soil particles are the primary processes of soil erosion. Understanding the mechanisms and extent of water erosion is crucial to manage and develop erosion control practices. Splash, sheet, rill and gully erosion are main forms of soil erosion by water. The other forms of water erosion are ravine formation, slip, tunnel, stream bank, and coastal erosion. The different forms of water erosion are described below:

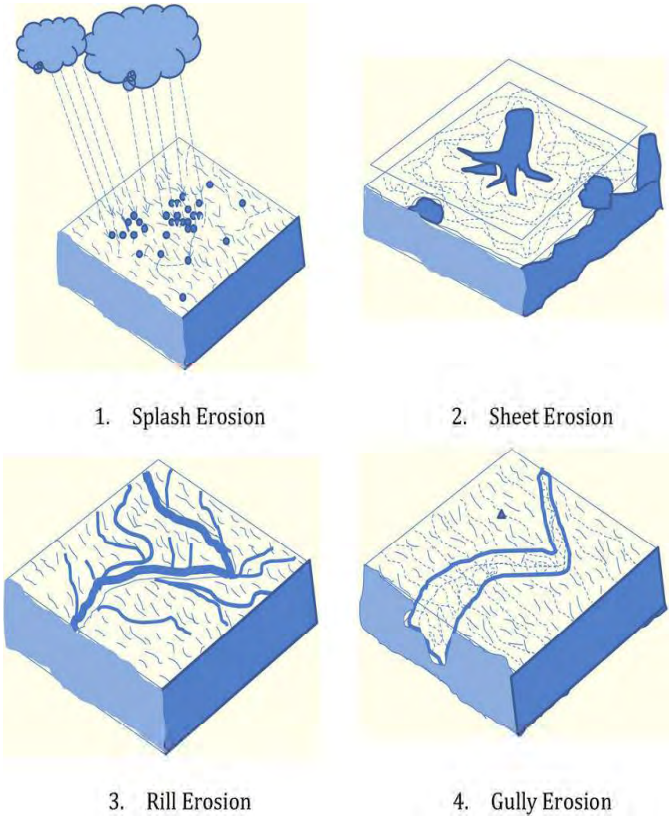

Figure:2 Types of Soil Erosion

Ravine formation:

It is referred to as a network of deep and narrow gullies that flows parallel to each other while linking with the river system. Mismanagement and non-judicious use of land result in enlargement of rills and gullies and eventually lead to ravine formation. Abrupt changes in elevation of the river bed and the adjoining land surface, deep and permeable soil with high erodibility, sparse vegetation, and backflow of river water during the recession period causes severe bank erosion which consequently results in ravine formation.

Figure:3 Ravine Formation (Enlargement of Gullies to Ravine)

Tunnel Erosion:

It is the sub-soil erosion through runoff flow in channels while surface soil remains intact. Tunnel erosion is also known as pipe erosion and commonly occurs in arid and semiarid regions where the soil permeability for water varied with the soil profile. The further widening and deepening of tunnels form large gullies which degrade the productive agricultural lands. Soil with erodible characteristics, having sodic B horizon and stable A horizon are highly prone to tunnel erosion. Runoff flow through natural cracks and animal burrows initiates tunnel formation by infiltrating thorough dispersible subsoil layers. Seepage, lateral flow, and interflow are key indicators of tunnel erosion. It alters the geomorphic and hydrologic characteristics of the affected areas. Management practices for tunnel erosion are ripping, contour farming, vegetation including trees and deep-rooted grasses with proper fertilization and liming, consolidation of surface soil, and diversion of concentrated runoff.

Figure:4: *Tunnel Erosion*

Slip Erosion or landslip Erosion:

It is the downward and outward movement of slope forming materials composed of natural rocks and debris from sloppy lands. It is also known as mudslide or mass erosion. This type of erosion mostly occurs in hilly regions having water-saturated soils slips down the hillside or mountain slope. Banks along highways, streams, and ocean fronts are often subject to landslides. The large masses of land slip down which destroy the vegetation and degrade the productivity of lands. The slope can be stabilized through developments of diversion drains, contour trenches, crib structures, geotextiles, kutta—crate structures, and retaining walls.

Fig:5 Slip Erosion or Land Slip Erosion

Stream Bank Erosion:

The scouring of soil material from the stream bed and cutting of stream bank by the action of flowing water is known as stream bank erosion. Streams and rivers change their direction of flow by cutting the bed from one side and depositing the sediment to the other side of the stream. Flash floods enhanced the stream bank erosion which is more destructive. Stream and gully erosion are relatively comparable. Primarily, stream bank erosion predominantly occurs at the lower end water tributaries which have a relatively flat slope and continuous flow of water.

Figure : 6- Stream or Bank Erosion

Coastal Erosion:

Sea level is incessantly rising due which can increase the frequency of occurrence of natural disasters like the tsunami in the coastal areas in the future. Such natural hazards produce strong water waves which can severely erode the seaside areas. It is projected that the erosion rate will be higher in coastal regions in the coming years. The anthropogenic activities leading to coastal erosion are port construction, destruction of mangroves, and beach and river bed mining.

Figure: 7 Coastal Erosion

Wind Erosion:

Deflation is the main way that wind causes erosion. Deflation is the process by which wind picks up sediment from the surface. The stronger the wind, the bigger the pieces of sediment the wind can pick up. Wind may carry away all the sediment in a desert and leave behind only rocks. Wind erosion is a natural process that moves soil from one location to another by wind power. It can cause significant economic and environmental damages.

Figure : 8 Wind Erosion (deflation).

Understanding on Universal soil loss equation for soil erosion

The universal soil loss equation (USLE) was given by Wischmeier and Smith (1978) based on the soil erosion causing factors:

A=RKLSCP

where A, mean annual soil loss (metric tons /hectare/ year); **R, rainfall erosivity factor; K, soil erodibility factor, L, slope-length factor, S, slope-steepness factor; C, cover and management factor; P, support practice factor.**

Among the above-listed factors, vegetation and to some extent soil can be managed to reduce the rate of the soil erosion but the climatic and topographic factors, except slope length, are not manageable. Primarily, soil loss through erosion is a function of erosivity of raindrops and erodibility of the soil which can be mathematically expressed as follows:

Erosion=f (Erosivity, Erodibility)

Where, Erosivity is the potential of rainfall to cause erosion under given soil type and climatic condition; Erodibility is the vulnerability or susceptibility of the soil to erosion which depends on soil bio-physico-chemical properties, and land use and crop management practice. Sandy soils can be easily detached while well aggregated clayey soils are more resistant to erosion than sandy soils. When clay particles detached, they can be easily removed by runoff due to their smaller size. Silt soils are the most erodible type of soil.

Impact of Soil Erosion on Agriculture

The accelerated soil erosion significantly influences the soil quality, agricultural production and nutritional quality. Higher soil erosion results in the removal of fertile topsoil along with nutrients which leads to reduced agronomic yield, land degradation, and terrain deformation. The main causal factors affecting the rate of soil erosion are parent material, soil texture, slope steepness, plant cover, tillage, and climate.

Moreover, the intensive and erratic rainfall results in higher soil erosion which leads to reduced infiltration and eventually less water availability to the vegetation. Thus, the soil loss by water and wind severely affects the productive efficiency of all ecosystems. The comprehensive impacts of erosion on soil and water resources which are liable to reduce agricultural productivity in higher order.

Impact of Erosion on soil and Water resources.

The vegetation cover is imperative for moderating surface runoff and water erosion from agricultural lands. The rate of runoff, soil, and nutrient loss is predominantly determined by the type of vegetation, canopy cover, slope gradient, and rainfall characteristics. The higher canopy cover and crop residues mulching on soil surface results in the reduced rate of surface runoff and also reduces the impact of rainfall erosivity and soil erodibility. Vegetation cover reduces the detachment of soil particles along with the protection of soil surface from intensive rainfall. Moreover, it also conserves soil moisture and retains sediment and organic materials. To sustain agricultural productivity, it is imperative to reduce runoff, soil loss, and nutrient loss through water erosion.

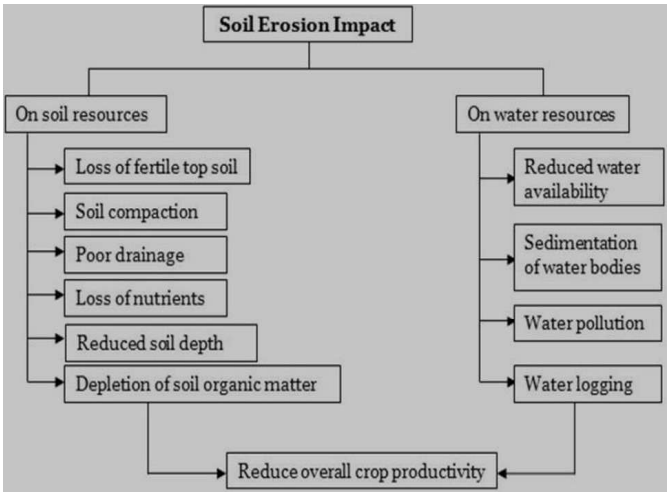

Fig: 9: Soil Erosion impacts on Soil and Water resources.

Fig 9.A Impact of Soil Erosion

Pertinent issues in Land and Water Resource Management:

Human pressure on land, soils and freshwater have intensified, pushing these resources to their production limits. Climate change has increased pressure on rain-fed and irrigation production over and above the environmental consequences of decades of unsustainable use. In the 30-40 years since the green revolution of intensive irrigation and other inputs reached its objective of growing more food, the reality has set in is that such single sector action has devastated biological diversity and depleted and degraded precious surface and groundwater resources. Careless use of agriculture land and deforestation have increased land degradation and reduced crop productivity.

The concept of IWRM (Integrated water resource management) was developed by water sector people and not sufficiently integrated with the agricultural and land use community. Lack of sound surface and groundwater governance has made the situation worse when coupled with increases in droughts and floods as climate changes. Water resources will continue to decline until agriculture and land use interests work together in a participatory fashion on a hydrologic unit basis or watershed basis.

Integrated land and water resources management wherein, Aquifers have no hope of sustainability until growers, producers, and pastoralists become active members of the water community to protect sensitive recharge areas. Co-management will become more of a reality because there is no other option with the decline in water resources.

Over the last several decades, many policies and best practices have been identified to reverse land degradation, save water irrigation, combat deforestation and desertification, and integrate land into water resources management. World leaders have come together to adopt the SDGs and provide new political will for action to achieve poverty reduction, sustainable land management, and sustainable water management. Serious perturbations of climate with increased droughts and floods have devastated countries and economies providing another driving force for action climate change adaptation.

Fig 9.B Soil Erosion and Land Degradation

Integrated land and water resource development policies and practices needs political will and huge resources now. While improved IL&WRM measures and associated polices need to be up-scaled as soon as possible, there is an associated set of interventions need to be worked on the longer term with politically sensitive policy issues. Land tenure reform, gender issues involving land rights, water rights and allocation systems, pricing policies, review on agricultural subsidies etc. The concept of "**Land and water is livelihood"** to be the core concept to be dealt with multidisciplinary and integrated approach, whereby significant opportunities for livelihood enhancement exist through the restoration and management of the available natural resources basically land, water and forest recourses in the rural areas.

Land Capability classification:

Land capability survey was devised by the **Commonwealth Scientific and Industrial research Organisation (CSIRO)** for demarcation of land capability regions of Australia. Subsequently the capability survey was widely applied in European and Anglo-American countries and in some of the Third World Countries.

Land capability may be defined as the ability of the land surface to support natural plant growth/ wildlife habitat or artificial crop growth/ human habitat. Thus, it indicates the type of land use [viz., human habitation, agriculture, pastures, forests, wildlife habitat, etc.] that is suitable over a particular type of land.

Land capability survey helps in ascertaining the usefulness of land, its utility for agriculture, forest, industry, tourism, and other land use purpose.

For the delineation of land capability regions, only physical parameters are taken into consideration. The demarcation of these regions in fact is on the basis of texture, structure of soil, terrain, slope, run-off, temperature, and precipitation. Thus, in the land capability survey, there is a heavy reliance on the results of soil survey in pedagogical conditions.

In general, each soil group has its own physical and chemical properties. These properties determine the land capability and land suitability. For example, the regur soil is good for the cultivation of cotton, sugarcane and citrus fruits, while the alluvial soil is utilized for wheat, rice, maize, sugarcane, pulses, and oilseeds.

In India, the basic objective of the soil survey was to achieve the land capability classification. The All-India Soil and land Use Survey Organization attempted the land capability survey in 1960 which identified eight land use capability classes.

Land Suitable for Cultivation:

Class I: Very good arable land with no specific difficulty in farming. It is nearly levelled, well drained, easily worked soil. These soils are very productive.

Class II: Good cultivation land which needs protection from erosion or floods, drainage improvement and conservation of irrigation water, intensive drainage, and protection from floods.

Class III: Moderately good cultivation land where special attention has to be paid to erosion control, conservation of irrigation water, intensive drainage, and protection from floods.

Class IV: Fairly goof land suited for occasional and limited cultivation. It needs intensive erosion control, intensive drainage and very intensive treatment to overcome the soil limitations.

Land Not Suitable for Cultivation:

Class V: Very well suited for grazing and forestry but not for cultivation of crops. It has very good carrying capacity of livestock but needs protection from gullying.

Class VI: Well suited for grazing and forestry but not for cultivation of crops. It has moderately carrying capacity of livestock. This land has steep slope, severe erosion, and stoniness, poor moisture retaining capacity, salinity and severe climate.

Class VII: Fairly well suited for grazing or forestry with little carrying capacity of livestock.

Class VIII: Suited only for wildlife. This land has severe climate, wet soil, stones, badlands, sandy beaches, marshes, deserts, and nearly barren lands.

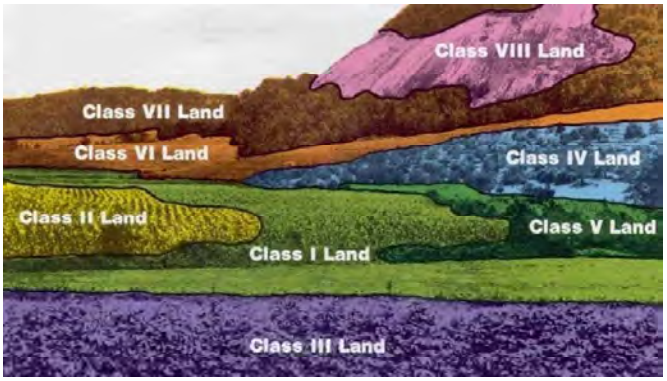

Figure:10 Land Capability classification

Significance of Land Capability Classification in Land use Planning:

The land capability classification determines the use ceiling for any piece of land and helps to define the conservation problems and possible treatments. Keeping this in mind, a piece of land can be put to the most efficient land use. For instance, all agricultural activity must be confined to classes I to IV and others, such as pasturelands, energy plantation, buildings, roads, etc., to classes V to VIII. Within this scheme, one can select the most suitable crop for a particular piece of land.

The land capability classes can change towards better classes, if the existing limitations can be permanently removed or reduced in extent by economically feasible reclamation measures, such as providing irrigation, providing proper drainage, constructing flood-control measures or stabilizing, gullies. A further deterioration of existing conditions can, on the other hand, shift the capability to poorer classes.

Concepts on land (Soil) and Water conservation and its Needs:

The land is finite and diminishing gradually due to the increasing rate of varied kinds of degradation and thus there is no alternative to expend cultivable land area. The only way is either increasing agricultural productivity per unit resource available or restoring the degraded lands. Healthy soil and availability of water are vital for productivity in all kinds of terrestrial ecosystems because plants require fertile soil with improved bio-physico-chemical properties and good quality of water for their growth and development. Use of soil and water conservation measures including biological (agroforestry and agricultural) and mechanical measures (terracing, bunding, trenching, check dams, etc.) is imperative to reduce runoff, soil erosion and to improve soil quality, water quality, moisture conservation, and overall crop productivity in a sustainable way. Biological measures are economically feasible and environmentally friendly; also improve soil properties along with the conservation of soil and water resources. Further, the combined use of biological and mechanical measures will help in improving and sustaining agricultural productivity. Soil and water conservation are those activities at the micro watershed level which maintain or enhance the productive capacity of the land including soil, water and vegetation in areas prone to degradation through

- **To control runoff/ Prevention or reduction of soil erosion, compaction, salinity;**
- **Conservation of drainage/runoff of water and to harvest Excess rainwater,**
- **Maintenance or improvement of soil fertility and land capability.**

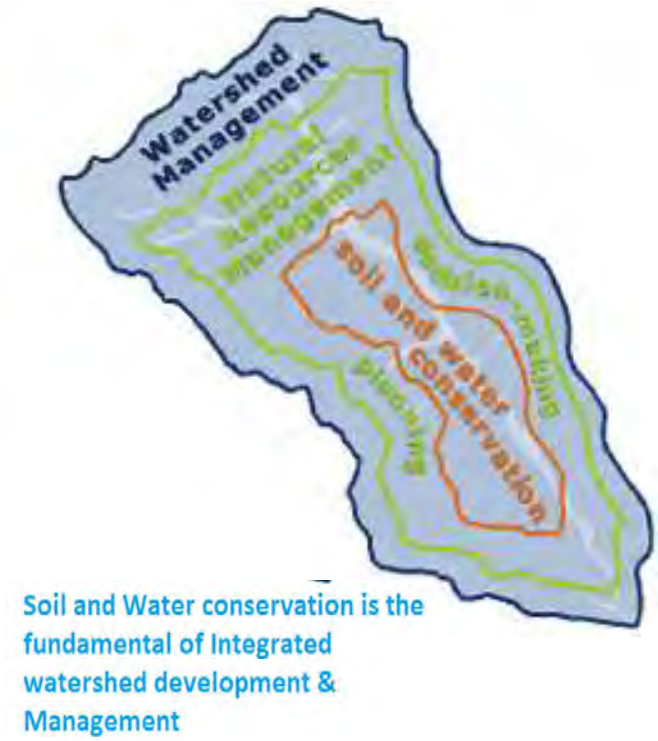

Figure:11. Soil and water conservation measures as part of Integrated watershed management

The elaborative Needs of Various Soil and Water conservation measures are as follows:

- Managing the river/stream flow regime to provide overall benefits such as reducing river bank, erosion, decreasing sediment transport and accumulation and improving water quality.
- Maintaining an adequate supply of water to meet demands for irrigation, agriculture, as well as domestic and industrial uses at acceptable levels of assurance.
- Maintaining water quality criteria that meet government statute/ standards and other societal Norms
- Land utilization based on land capability.
- Top fertile soil protection.
- Reducing the silting in reservoirs and dams.
- Keeping vegetative cover, whole the year.
- Rain water harvesting and conservation as per location specific conditions.
- Proper drainage facility for excess run off water.
- Construction of check dams and other water conservation and recharge measures for life-saving irrigation.
- Increasing ground water recharge and Enhancing storage,
- Inter and sequence cropping,
- Efficient use of marginal lands.
- Maintaining the sustainability of ecosystem,
- Increasing farm income through integrated farming system by appropriate Soil and water conservation measures,
- Practicing alternate land use systems,
- Reducing vulnerability to natural disasters such as floods, droughts and landslides.
- Utilizing natural resources effectively to mitigate adverse effects, prevent environmental degradation, enhance water yield and increase biomass production.
- Promoting appropriate agricultural and forestry land use practices and associated soil and water conservation measures that allow production levels that provide sufficient water and soil moisture
- income to land users without causing any long-term negative impacts on the natural resources of the watershed.
- Distributing the benefits of land and water resources development more equally amongst the stakeholders
- To promote Social and Economic development
- To decrease local vulnerability to climatic extremes
- To ensure maintenance of Environment and biodiversity.

The Land and Water resources development in a watershed is attributed to the various soil and water conservation measures taken up in the watershed. Thus, the soil and water resources conservation are considered as a fundamental aspect of watershed development and management.

The various aspects of soil and water resources conservation measures are broadly classified in to Physical, Biological and agronomic Measures.

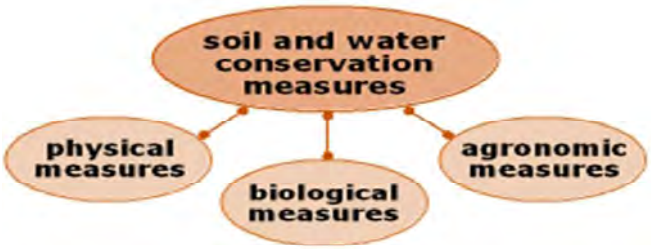

Figure: 12. Various aspects of Soil and water conservation

The various soil and water conservation measures are as detailed below:

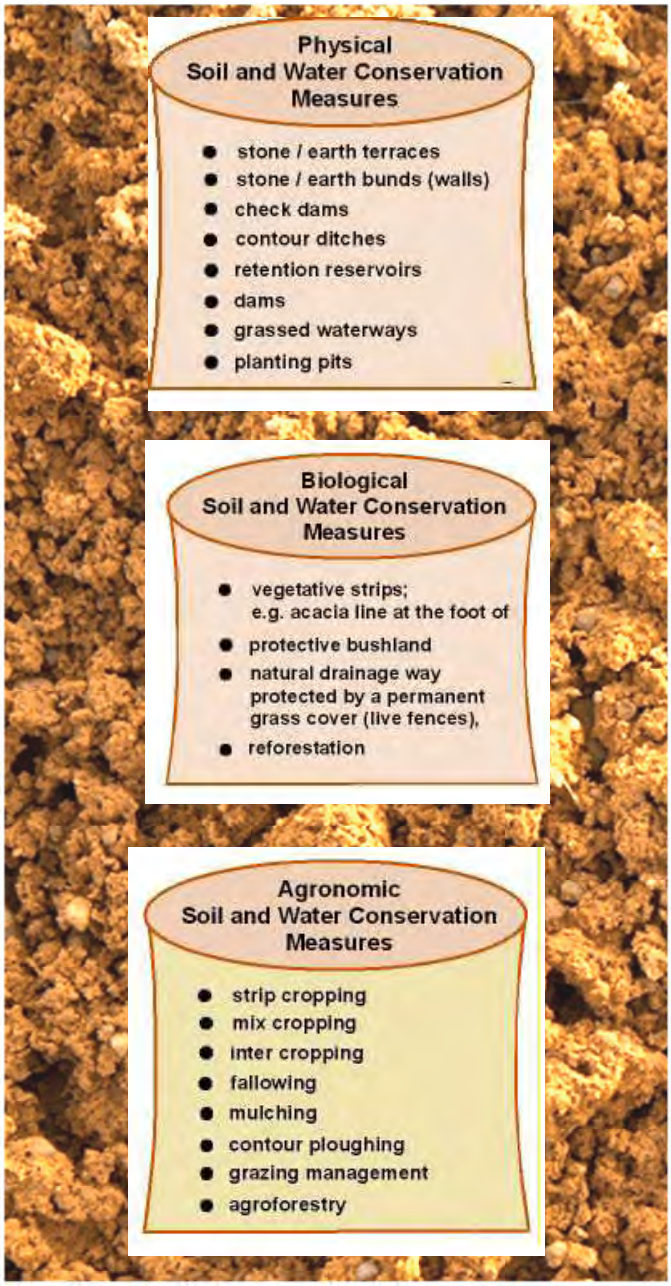

Figure: 13 Various Conservation Measures

Soil and water conservation measures:

There are three types of measures for soil and water conservation, that is, Mechanical, Engineering. Structural measures, biological measures and agronomic. Mechanical measures are permanent and semi-permanent structures that involve terracing, bunding, trenching, check dams, gabion structures, loose/stone boulders, crib wall, etc., while biological measures are vegetative measures which involve forestry, agroforestry, horticulture and agricultural/agronomic practices

Mechanical measures:

Mechanical measures or engineering structures are designed to modify the land slope, to convey runoff water safely to the waterways, to reduce sedimentation and runoff velocity, and to improve water quality. These measures are either used alone or integrated with biological measures to improve the performance and sustainability of the control measures. In highly eroded and sloppy landscape biological measures should be supplemented by mechanical structures. A number of permanent and temporary mechanical measures are available such as terraces, contour bunding, check dams, gabions, diversion drains, geotextiles, etc. The mechanical measures are preferred based on the severity of erosion, soil type, topography, and climate.

Bunding:

I. Contour bunding: Contour bunding is used to conserve soil moisture and reduce erosion in the areas having 2–6% slope and mean annual precipitation of <600 mm with permeable soils. The vertical interval between two bunds is known as the spacing of bunds. The spacing of bund is dependent on the erosive velocity of runoff, length of the slope, slope steepness, rainfall intensity, type of crops, and conservation practices.

ii. Graded bunding: Graded bunds are made to draining out of excess runoff water safely in areas having 6–10% land slope and receiving rainfall of >750 mm with the soils having infiltration rate < 8 mm/h.

iii. Peripheral bunds: Peripheral bunds are constructed around the gully head to check the entry of runoff into the gully. It protects the gully head from being eroded away through erosion processes. It creates a favorable condition for the execution of vegetative measures on gully heads, slopes, and beds.

Contour Bunding **Graded Bunding** **Peripheral Bunding**

Figure: 14: Types of Bunding

Contour trenching:

Trenches are constructed at the contour line to reduce the runoff velocity for soil moisture conservation in the areas having <30% slope. Bunds are formed on the downstream side of trenches for the conservation of rainwater. Trenches are of two types:

Continuous contour trenches:

Continuous contour trenches are constructed based on the size of the field in the low rainfall areas with the 10 –20 cm trench length and 20–25 cm equalizer width without any discontinuity in trench length (10–20 m).

Staggered contour trenches (STCs):

Generally, these trenches are constructed in alternate rows directly beneath one another in a staggered manner in the high rainfall areas, where the risk of overflow is prominent. SCTs are 2–3 m long with 3–5 m spacing between the rows. Planting of tree species is done based on the land slope. It is highly effective in forestalling extension of gully head, soil loss, and arrest the overflow

Continuous Contour Trenches | Staggered Contour Trenches

Figure: 15- Types of Trenches

Terracing:

Terraces are earthen embankments built across the dominant slope partitioning the field in uniform and parallel segments. Generally, these structures are combined with channels to convey runoff into the main outlet at reduced velocities. It reduces the degree and length of slope and thus reduced runoff velocity, soil erosion and improves water infiltration. It is recommended for the lands having a slope of up to 33%, but can be adopted for lands having up to 50–60% slope, based on socio-economic conditions of a particular region. Where plenty of good-quality stones are available, stone bench terracing is recommended. Sometimes, semi-circular type terraces are built at the downstream side of the plants, known as half-moon terraces. Based on the slope of benches, the bench terraces are classified into the following categories:

Bench terraces sloping outward: These types of terraces are used in low rainfall areas having permeable soils. A shoulder bund is provided for stability of the edge of the terrace and thus has more time for rainwater soaking into the soil.

Bench terraces sloping inward (hill-type terraces): These types of bench terraces are suitable for heavy rainfall areas where a higher portion of rainfall is to be drained as runoff. For this, a suitable drain should be provided at the inward end of each terrace to drain the runoff. These are also known as hill-type terraces.

Bench terraces with level top: These types of terraces are suitable for uniformly distributed medium rainfall areas having deep and highly permeable soils. These are also known as irrigated bench terraces because of their use in irrigated areas.

Figure: 16 - Terracing cultivation

Contour wattling:

Wattling is a technique of dividing the length of the slope into shorter sections and in these sections, the wattles are constructed at a vertical interval of 5–7 m up to 33% slope and 3 m up to 66% slope. It is not effective on slopes steeper than 66% and on very loose or powdery rocks.

Figure : 17-*Contour Wattling as part of Soil Bio- Engineering Measures*

Crib structures:

Crib structures are used to stabilize the steep slopes of >40% by constructing log wood structures filled with stone/brushwood. Eucalyptus poles with 2–3 m length and 8–12 cm diameter can be used for the construction of crib structures. These poles are joined together with the help of 20–25 cm long nails. The height of the structure is kept 1.5–2 m above the ground depending upon the land slope.

Geo-textiles:

Geo-textiles are made up of natural fibers of jute or coir, which are used for stabilization of degraded slopes in mine spoil and landslides areas along roadsides. Coir geotextiles are made from coconut fibre extracted from the husk of coconut. Like other polymeric counterparts, coir geotextiles are developed for specific application in civil engineering like erosion control, ground improvement, filtration, drainage, river bank protection, road pavements, slope stability etc. It facilitates the initial establishment of vegetation on highly degraded sloping lands by holding the vegetation in place and conserving moisture. The open mesh size of geo-textiles varies from 3 to 25 mm. The biodegradability of geo-textiles was reported for 2–3 years. It can absorb 12–25% water under 65 and 95% humidity, respectively and when fully soaked in water it can absorb 40% moisture.

Figure : 18 - Coir Geotextile for Slope stabilization

Loose boulder/stone/masonry check dams:

Check dams are effective for preventing runoff rate and severe erosion in steep and broad gullies, and most suitable for high elevation areas of the catchment. These structures are cheap, having a long life, and fewer maintenance requirements. The depth of gully bed is kept about 0.3 m and flat stones of 20–30 cm size are used for the construction of dams. A spillway is provided in the middle of the dam to allow the safe discharge of runoff water. Similarly, gabion check dams are also used for drainage line treatment in sharp slanted gullied areas to check sedimentation, erosion, and to conserve soil moisture.

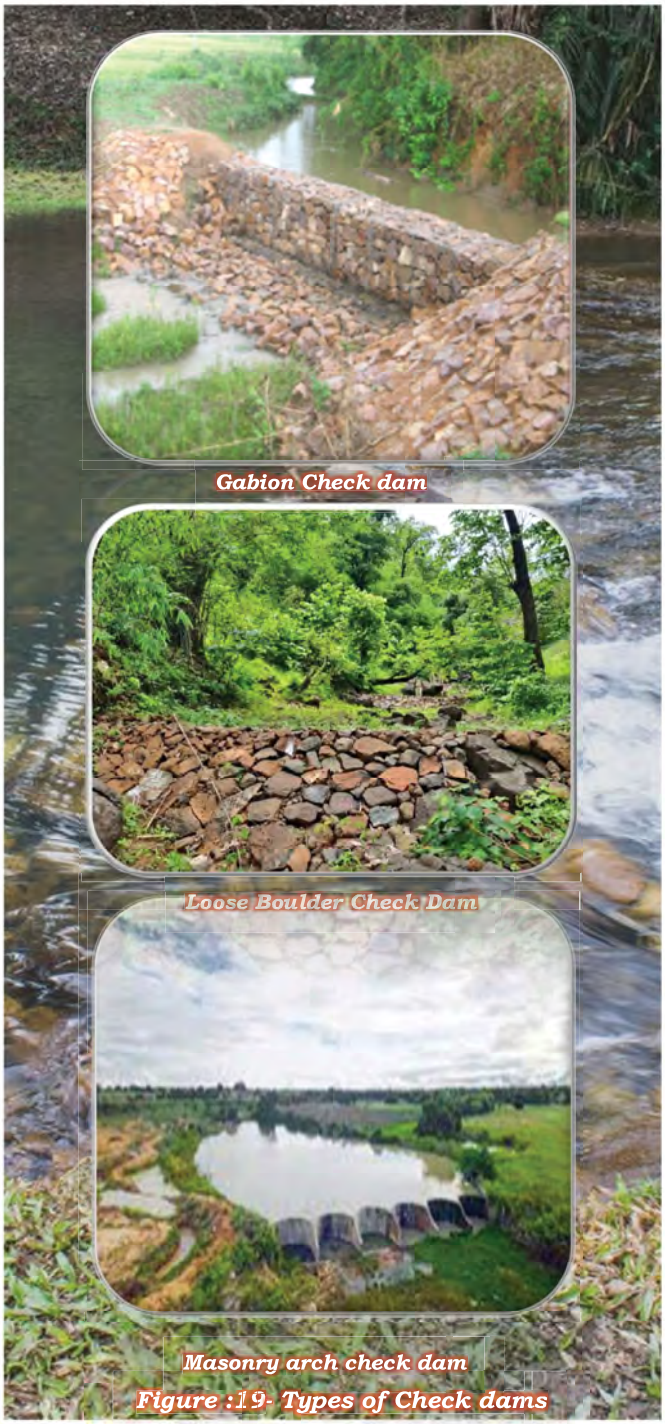

Figure :19- Types of Check dams

Brushwood check dams:

Branches of tree and shrub species are staked in two rows parallel to each other filled with brushwood and laid across the gully or way of the flow. These are usually built to regulate the overflow in small and medium gullies which are supplemented with vegetative barriers for long term effectiveness. There is enough soil volume to establish the vegetation. The tree species are planted in 0.3 m × 0.2 m trenches across the way of gullies. It reduces the runoff velocity, soil loss, and improves soil moisture which helps in the successful establishment of vegetative barriers.

Figure : 20- Brushwood Check dam on field

Diversion drains:

The channels are constructed to protect the downstream area and for safe draining and diverting of runoff water. It is applicable in high rainfall areas to control runoff losses during the initial stage. The gradient of diversion drain should preferably be kept within 0.5%. Generally, a narrow and deep drain does not get silted up as rapidly as a broad and shallow drain of the same cross-sectional area. Soil dug from the drain should be dumped on the lower side of the drain. Outlet end should be opened at natural drainage lines.

Figure: 21- Construction of Diversion Drain on field

Percolation Ponds/tanks:

Percolation ponds are small ponds located mostly in low lying areas of watershed and formed in order to store the run-off of rainwater and to allow it to percolate downwards and sideways. Deep ponds are preferred since evaporation of the stored water will be lessened. It recharges the groundwater regime and soil moisture zones.

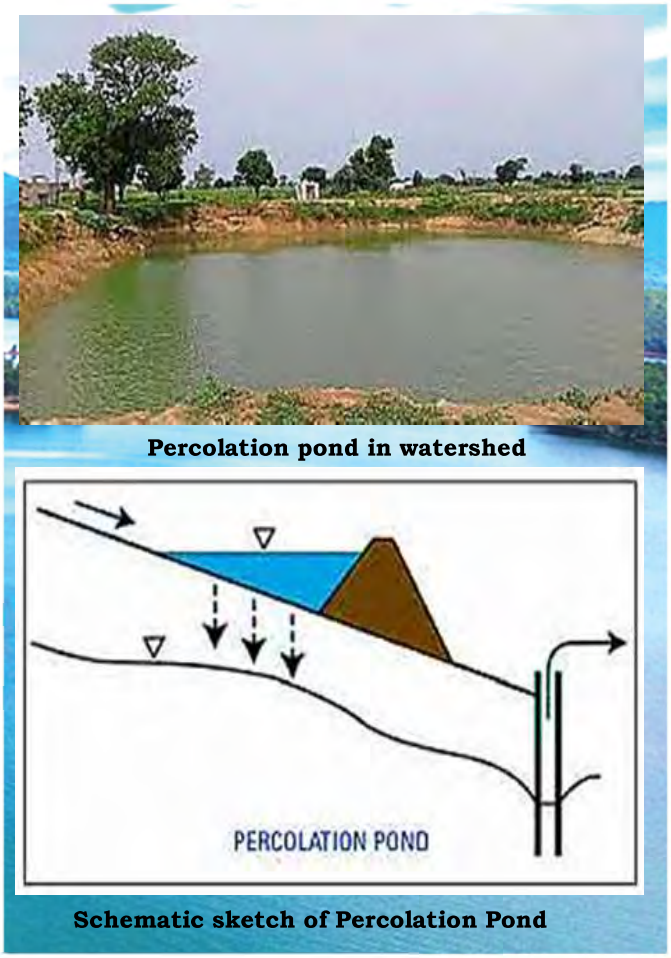

Figure 22- Percolation pond

Conservation Bench terrace:

In the conservation bench terrace (CBT) system, the land is divided into 2:1 ratio along the slope in which the upper 2/3 area (Donor area) contributes runoff to the lower 1/3 runoff collecting area (recipient area). The donor area is left in its natural slope condition. It is also known as the zing terrace and developed by Zingg and Hauser in 1959. The runoff contributing area is used for cultivation of kharif while the lower 1/3 area with conserved soil moisture is used to cultivate rabi crops. This mechanical measure can be successfully applied in a semi-arid climate on mild sloppy lands (2–5%) for erosion control, water conservation, and improvement of crop productivity. This system can be used in silty loam to silty clay loam soils. CBT system resulted in the reduction of runoff from 36.3 to 7.4% and soil loss from 10.1 to 1.19 Mg ha−1 as compared to the conventional system of sloping border. An average reduction of 78.9 and 88.0% in runoff and soil loss, respectively reported in the CBT system over the conventional system.

Figure: 23- Bench Terracing

Biological measures (agronomic/agricultural and agroforestry)

Agronomic measures are applicable in the landscape of ≤2% slope. Agronomic measures reduce the impact of raindrops through the covering of soil surface and increasing infiltration rate and water absorption capacity of the soil which results in reduced runoff and soil loss through erosion. These measures are cheaper, sustainable, and may be more effective than structural measures, sometimes

Important Agronomic measures are described below.

Contour farming:

Contour farming is one of the most commonly used agronomic measures for soil and water conservation in hilly agro-ecosystems and sloppy lands. All the agricultural operations viz. plowing, sowing, inter-culture, etc., are practiced along the contour line. The ridges and furrows formed across the slope build a continual series of small barriers to the flowing water which reduces the velocity of runoff and thus reduces soil erosion and nutrient loss. It conserves soil moisture in low rainfall areas due to increased infiltration rate and time of concentration, while in high rainfall areas, it reduces the soil loss. In both situations, it reduces soil erosion, conserves soil fertility and moisture, and thus improves overall crop productivity. However, the effectiveness of this practice depends upon rainfall intensity, soil type, and topography of a particular locality.

Figure 24- Contour Farming Practices

Choice of crops:

The selection of the right crop is crucial for soil and water conservation. The crop should be selected according to the intensity and critical period of rainfall, market demand, climate, and resources of the farmer. The crop with good biomass, canopy cover, and extensive root system protects the soil from the erosive impact of rainfall and create an obstruction to runoff, and thereby reduce soil and nutrient loss. Row or tall-growing crops such as sorghum, maize, pearl millet, etc. are erosion permitting crops which expose the soil and induce the erosion process. Whereas close growing or erosion resisting crops with dense canopy cover and vigorous root system viz. cowpea, green gram, black gram, groundnut, etc. are the most suitable crops for reducing soil erosion. To increase the crop canopy density, the seed rate should be always on the higher side.

Crop rotation:

Crop rotation is the practice of growing different types of crops in succession on the same field to get maximum profit from the least investment without impairing the soil fertility. Mono cropping results in exhaustion of soil nutrients and deplete soil fertility. The inclusion of legume crops in crop rotation reduces soil erosion, restores soil fertility, and conserves soil and water. Further, the incorporation of crop residue improves organic matter content, soil health, and reduces water pollution. A suitable rotation with high canopy cover crops helps in sustaining soil fertility; suppresses weed growth, decreases pests and disease infestation, increases input use efficiency, and system productivity while reducing the soil erosion.

Cover crops

The close-growing crops having high canopy density are grown for protection of soil against erosion, known as cover crops. Legume crops have good biomass to protect soil than the row crops. The effectiveness of cover crops depends on crop geometry and development of canopy for interception of raindrops which helps in reducing the exposure of soil surface for erosion. It has been reported that legumes provide better cover and better protection to land against runoff and soil loss as compared to cultivated fallow and sorghum. The most effective cover crops are cowpea, green gram, black gram, groundnut, etc.

Advantages:

- Protection of soil from the erosive impact of raindrops, runoff, and wind.
- Act as an obstacle in water flow, reduce flow velocity, and thereby reduce runoff and soil loss.
- Increase soil organic matter by residue incorporation and deep root system.
- Improve nutrients availability to the component crop and succeeding crops through biological nitrogen fixation.
- Improve water quality and water holding capacity of the soil.
- Improve soil properties, suppress weed growth, and increase crop productivity.

Intercropping

Cultivation of two or more crops simultaneously in the same field with definite or alternate row pattern is known as intercropping. It may be classified as row, strip, and relay intercropping as per the crops, soil type, topography, and climatic conditions. Intercropping involves both time-based and spatial dimensions. Erosion permitting and resisting crops should be intercropped with each other. The crops should have different rooting patterns. Intercropping provides better coverage on the soil surface, reduces the direct impact of raindrops, and protects soil from erosion.

Advantages:

- High total biomass production.
- Efficient utilization of soil and water resources.
- Reduction of marketing risks due to the production of a variety of products at different periods.
- Drought conditions can be mitigated through intercropping.
- Reduce the weed population and epidemic attack of insect pests or diseases.
- It improves soil fertility.

Strip cropping:

Growing alternate strips of erosion permitting and erosion resistant crops with a deep root system and high canopy density in the same field is known as strip cropping. This practice reduces the runoff velocity and checks erosion processes and nutrients loss from the field. The erosion resisting crops protects soil from beating action of raindrops, reduces runoff velocity, and thereby increased time of concentration which results in a higher volume of soil moisture and increased crop production. Strip cropping is practiced for controlling the run-off and erosion and thereby maintaining soil fertility.

Figure 26- Strip Cropping system on field

Types of strip cropping

- **Contour strip cropping:** The growing of alternate strips of erosion permitting and erosion resisting crops across the slopes on the contour is known as contour strip cropping. It reduces the direct beating action of raindrops on the soil surface, length of the slope, runoff flow and increases rainwater absorption into the soil profile.
- **Field strip cropping**: In this practice the field crops are grown in more or less parallel strips across fairly uniform slopes, but not on exact contours. It is useful on regular slopes and with soils of high infiltration rates, where contour strip cropping may not be practical.
- **Wind strip cropping:** It consists of the planting of tall-growing row crops (such as maize, pearl millet, and sorghum) and close or short growing crops in alternately arranged straight and long, but relatively narrow, parallel strips laid out right across the direction of the prevailing wind, regardless of the contour.
- **Permanent or temporary buffer strip cropping:** It is the growing of permanent strips of grasses or legume or a mixture of grass and legume in highly eroded areas or in areas that do not fit into regular rotation, i.e. steep or highly eroded, slopes in fields under contour strip cropping. These strips are not practiced in normal strip cropping and generally planted permanent or temporary basis.

Figure 27 Types of Mulching

Mulching:

Mulch is any organic or non-organic material that is used to cover the soil surface to protect the soil from being eroded away, reduce evaporation, increase infiltration, regulate soil temperature, improve soil structure, and thereby conserve soil moisture Mulching prevents the formation of hard crust after each rain. The use of blade harrows between rows or inter-culture operations creates "dust mulch" on the soil surface by breaking the continuity of capillary tubes of soil moisture and reduces evaporation losses. Mulching also reduces the weed infestation along with the benefits of moisture conservation and soil fertility improvement. Hence, it can be used in high rainfall regions for decreasing soil and water loss, and in low rainfall regions for soil moisture conservation. Organic mulches improve organic matter and consecutively improving the water holding capacity, macro and micro fauna biodiversity, their activity, and fertility of the soil. Inorganic mulches have a longer life span than organic mulches and can reduce soil erosion, water evaporation losses, suppress weeds but cannot improve soil health. This practice is costly and labor intensive therefore, suitable for cash crops such as fruits and vegetables. Polyethylene mulch is commonly used for the conservation of soil and water resources to increase crop productivity.

Conservation tillage:

In this practice at least 30% of soil surface should remain covered with crop residue before and after planting the next crop to reduce soil erosion and runoff, as well as other benefits such as C sequestration. This term includes reduced tillage, minimum tillage, no-till, direct drill, mulch tillage, stubble-mulch farming, trash farming, strip tillage, etc. The concept of conservation tillage is widely accepted in large scale mechanized crop production systems to reduce the erosive impact of raindrops and to conserve the soil moisture with the maintenance of soil organic carbon. Conservation tillage improves the infiltration rate and reduces runoff and evaporation losses. It also improves soil health, organic matter, soil structure, productivity, soil fertility, and nutrient cycling and reduces soil compaction.

Figure 28: Conservation Tillage system on field

Organic farming:

Organic farming is an agricultural production system that devoid the use of synthetic fertilizers or pesticides and includes organic sources for plant nutrient supply viz. FYM, compost, vermicompost, green manure, residue mulching, crop rotation, etc. to maintain a healthy and diverse ecosystem for improving soil properties and ensuring a sustained crop production. It is an environmentally friendly agricultural crop production system. The maintenance of high organic matter content and continuous soil surface cover with cover crops, green manure, and residue mulch reduce the soil erosion in organic farming. It leads to the addition of a large quantity of organic manures which enhances water infiltration through improved bio-physico-chemical properties of soil, and eventually reduces soil erodibility. Organic materials improve soil structure through the development of soil binding agents (e.g., polysaccharides) and stabilizing and strengthening aggregates which reduce the disintegration of soil particles and thus reduced soil erosion. Soil erosion rates from soils under organic farming can be 30–140% lower than those from conventional farming.

Land configuration techniques:

Adoption of appropriate land configuration and planting techniques according to crops, cropping systems, soil type, topography, rainfall, etc. help in better crop establishment, intercultural operations, reduce runoff, soil and nutrient loss, conserve water, efficient utilization of resources and result in higher productivity and profitability. Ridge and furrow, raised bed and furrow, broad bed and furrow, and ridging the land between the rows are important land configuration techniques.

Ridge and furrow system: Raising rainy season crops on ridges and Rabi season crops in furrows reduces the soil crusting and ensures good crop stand over sowing on flat beds. Moreover, inter-row rainwater can be drain out properly during the monsoon period and collected in farm ponds, for life-saving irrigations and profile recharging for the establishment of rabi crops. It leads to the increased moisture content in soil profile which reduces moisture stress on plants during the drought period. This method is most suitable for wide-spaced crops viz. cotton, maize, vegetables, etc.

Broad bed and furrow system: This system has been developed by the ICRISAT in India. It is primarily advocated for high rainfall areas (>750 mm) having black cotton soils (Vertisols). Beds of 90–120 cm width are formed, separated by sunken furrows of about 50–60 cm wide and 15 cm depth. The preferred slope along the furrow is between 0.4 and 0.8% on Vertisols. Two to four rows of the crop can be grown on the bed, and the width and crop geometry can be adjusted to suit the cultivation and planting equipment.

Figure 29: Board Bed and furrow system of cultivation

Advantages:

- Increase in-situ soil moisture conservation
- Safely dispose of excess runoff without causing erosion
- Improved soil aeration for plant growth and development
- Easier for weeding and mechanical harvesting
- It can accommodate a wide range of crop geometry.

Agroforestry measures:

Agroforestry is a sustainable land management system which includes the cultivation of trees or shrubs with agricultural crops and livestock production simultaneously on the same piece of land. It is an emerging technology for effective soil and water conservation and comprises a wide range of practices for controlling soil erosion, developing sustainable agricultural production systems, mitigating environmental pollution, and increasing farm economy. The leaf litter addition act as a protective layer against soil erosion improves soil health and moisture retention capacity of the soil and increases crop productivity. It has been reported that different agroforestry practices can reduce up to 10% of soil erosion. Agroforestry not only controls soil erosion but also produce tree-based several marketable products.

Types of agroforestry systems:

Agri-Silviculture: It is the growing of agricultural crops as a primary component with the secondary component of multipurpose trees (MPTs) on the same managed land unit. The tree species bind soil particles in the root zone and increase water infiltration, and reduce runoff.

Agri-Horticulture:

Growing of agricultural crops and fruit trees on the same managed land unit is known as agri-horticulture. Fruit tree species like lemon (Citrus limon), mango (Mangifera indica), ber (Ziziphus mauritiana), and aonla (Phyllanthus emblica) can be successfully planted in agricultural fields and on degraded and low fertile lands with some restoration measures.

Figure 30-Agro silviculture on field

Figure: 31 Agro- Horticulture on field

Figure: 32: Alley Cropping system on field

Alley Cropping: Growing of agricultural crops in the alley formed between the hedge rows of leguminous nitrogen-fixing tree species. This system is one of the effective measures for soil and water conservation in hilly areas.

Silvi-pasture System:

Raising grasses or livestock with MPTs on the same managed land unit is known as silvi-pasture system. This system has the potential to reclaim eroded and degraded lands. Mechanical measures combined with grass species cultivation are more effective for controlling soil erosion processes The grass species such as Cenchrus ciliaris (buffel grass), Cenchrus setigerus (birdwood grass), Dichanthium annulatum (marvel grass), Panicum antidotale (blue panicgrass), Panicum maximum (Guinea grass), Brachiaria mutica (para grass) and Pennisetum purpureum (elephant grass) are important in ravine restoration.

Conclusion:

The land is finite and diminishing gradually due to the increasing rate of varied kinds of degradation and thus there is no alternative to expend cultivable land area. The only way is either increasing agricultural productivity per unit resource available or restoring the degraded lands. Healthy soil and availability of water are vital for productivity in all kinds of terrestrial ecosystems because plants require fertile soil with improved bio-physico-chemical properties and good quality of water for their growth and development. Use of soil and water conservation measures including biological (agroforestry and agricultural) and mechanical measures (terracing, bunding, trenching, check dams, etc.) is imperative to reduce runoff, soil erosion and to improve soil quality, water quality, moisture conservation, and overall crop productivity in a sustainable way. Biological measures are economically feasible and environmentally friendly; also improve soil properties along with the conservation of soil and water resources. Further, the combined use of biological and mechanical measures will help in improving and sustaining agricultural productivity.

There should be State wise policy implications to be developed on surface and ground water exploitation for agriculture, domestic and industrial use to avoid over exploitation of water resources. Appropriate state wise strategies for augmentation of ground water recharge and its quantification and management needs to be derived for sustainable ground water availability. Deriving strategies for corporate social responsibilities for managing ground water resources will be another area where we can enhance the ground water recharge on micro watershed level interventions.

Studies on monitoring water availability and resource conservation impacts of watershed management programs needs to be strengthen across the country. Indigenous sensor-based equipment needs to be developed for monitoring surface and ground water resources on watershed basis. Priority should be given to identify, evaluate and refinement the water harvesting techniques in different agro-Ecological regions of the country to mitigate the climate change impact on water resources as part of micro water shed or small hydrological units. Studies should thoroughly concentrate on upstream downstream linkages at micro watershed scales for assessing impact of watershed management programs on flow Regimes (surface and ground water resources) and perenniality of streams and rivers needs to be initiated.

Figure 33- Silvi Pasture system on field.

Observational data and data access network to assess the recent experience in climate variability and extreme events, impacts of projected climate change and variability and associated hydrological events in watershed basin/ aquifer level needs to be strengthened. Impact of climate change on groundwater aquifers, including quality, recharges rates, and flow dynamics should be quantified. Also, immediate research studies to be initiated on impact of sea level rise on the coastal watershed /groundwater regime, vulnerability of water resources to climate change and identifying key risks and prioritizing the adaptation responses.

"***Participatory micro level Integrated Watershed development and effective Management processes will empower all stakeholders with essential knowledge on soil and water conservation, ensuring a long-term Sustainability of Natural Resource Management.***"

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Independent Review and Monitoring Agency (IRMA) Visit

IRMA inspecting WS work done in Parottukom area in Tvpm Corporation

MoHUA has entrusted National institute of Urban affairs (NUIA) as an Independent Review and Monitoring Agency (IRMA) of AMRUT 2.0 projects in Kerala. This initiative is part of our commitment to ensuring transparency, accountability, and the successful implementation of the AMRUT 2.0 projects across the state.

The out comes and suggestions put forth by IRMA has to be followed for corrective measures and getting the next course of fund release from MoHUA.

IRMA site inspection along with KWA officials

IRMA Team document verification at KWA Aruvikkara office

IRMA Team in Karunagappally Municipality

IRMA meeting with KWA MD, JMD and SMMU team at Jalbhavan Trivandrum

IRMA Team in Paravur Municipality

IRMA team at Punalur Municipality

IRMA site inspection along with KWA officials at Punalur

IRMA team at Kollam corporation

What Our Interns Say

"My internship as an IT and E-Governance intern at AMRUT Kerala was a transformative experience. I gained valuable exposure to urban governance systems and hands-on work with various technologies, shaping my career aspirations. The critical thinking, adaptability, and mentorship I gained during this time have been instrumental in my professional growth."

— Bhavya Ullas , IT & E-Governance Intern

"I contributed to monitoring and evaluating water supply and sewerage projects in Kerala, enhancing my project management, data analysis, and technical documentation skills while gaining insights into government initiatives and stakeholder collaboration".

— Midhun M B, Water and Waste Water Treatment Intern

"I gained practical experience in financial management, budgeting, and municipal accounting. The role enhanced my technical skills and understanding of public service, while providing valuable insights into revenue and expenditure management. I'm grateful for the mentorship, which contributed to my growth and deepened my interest in urban development".

— Sreelekshmi N , Municipal Finance Intern

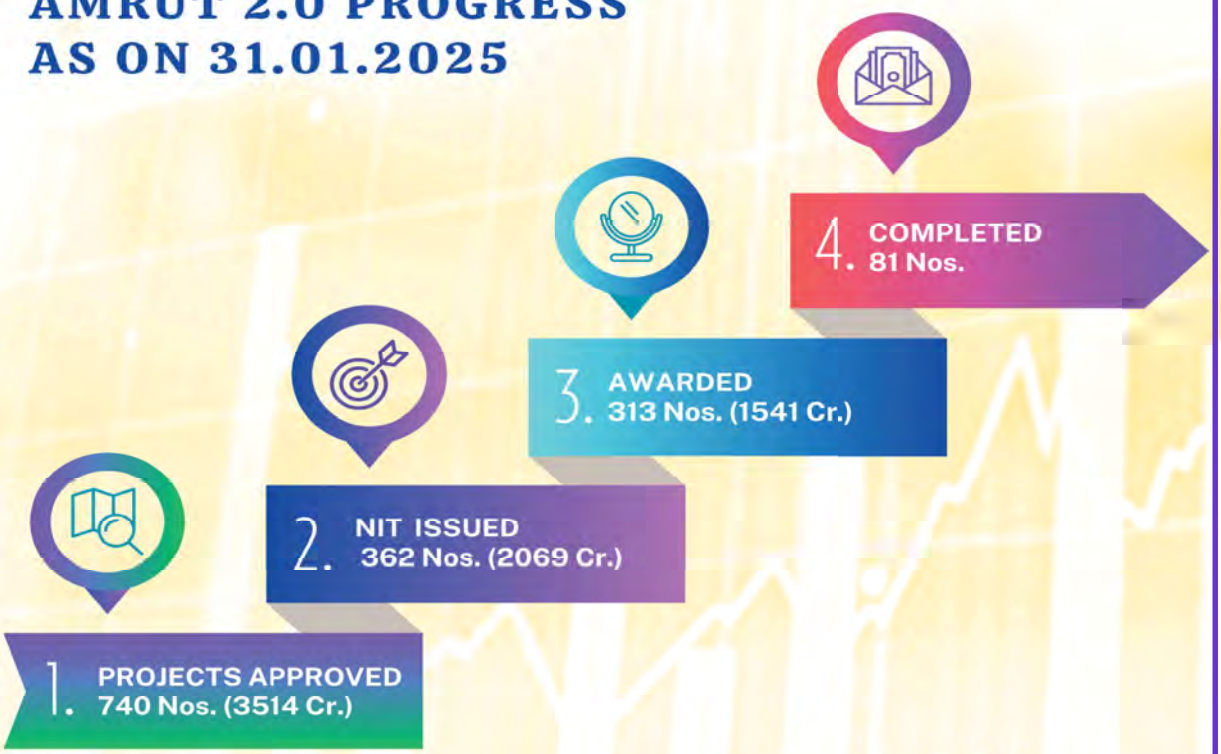
"My internship at AMRUT Kerala has been a great learning experience. I got to improve my IT skills while working on important projects for urban development. The team is supportive, and the work is meaningful, making it a wonderful place to grow and contribute".

— Athira A , IT & E-Governance Intern

AMRUT 1 PROGRESS AS ON 31.01.2025

EXPENDITURE : 2212.22 Cr.

AMRUT 2.0 PROGRESS AS ON 31.01.2025



EXPENDITURE : 382 Cr.

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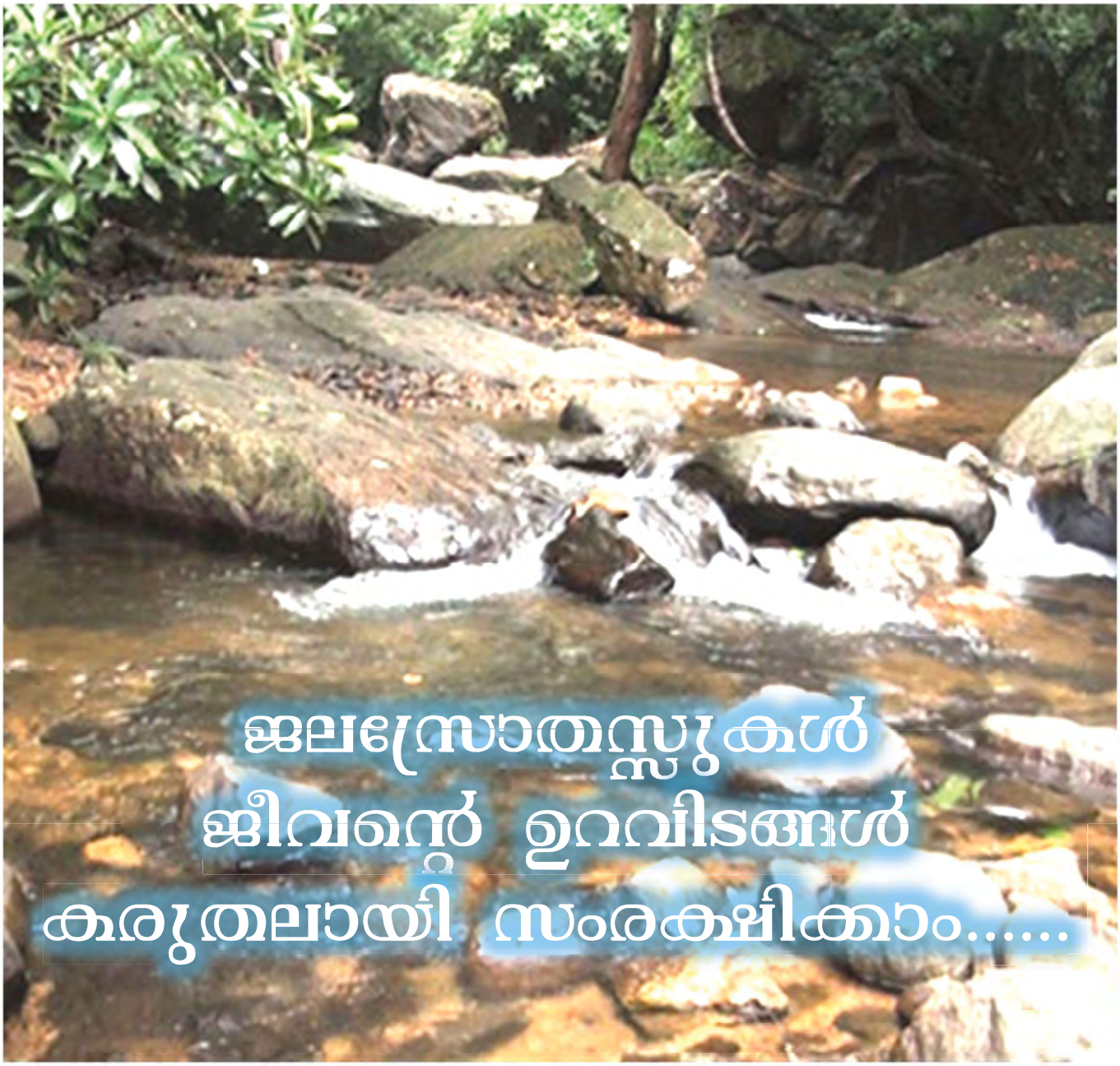

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