Geomatics Applications for Farm's Sustainability

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Abstract: Kazakhstan, like many countries in the world, experienced big floods this Spring 2024. Big droughts could occur during the summer of 2024, even worse than it was in 2023. These devastating droughts occurred during the last several years from 2020, causing big losses for Kazakhstan's farmers. Floods-droughts disasters, connected to climate change and anthropogenic disruptions, require the proper mitigation strategies, programs, and technologies. Engineering efforts, such as intervention in the natural water movement should be chosen carefully. Intervention in nature must be prudent and rational, the mitigation output should lead to increased processes of adaptation, not destruction. It is critical to predict and to reliably model in advance how nature will react to man's intervention in the existing equilibrium. Unfortunately, most of the flood mitigation activities in Kazakhstan are still based mostly on fighting with nature– settlements in flood zones and dam constructions. This also includes intensive exploitation of once fertile lands and the very geometric locations of settlements, shape of farm plots: rectangular, without considering the terrain, increased erosion, and diminish the natural water movement. A more rational, sustainable approach is to consider the local topography when dividing land combined with planting forest belts. The contour-strip organisation of the territory for the division of the catchment into several contour strips along horizontal lines combined with the Flood-MAR (Managed Aquifer Recharge) technologies are a more sustainable approach to mitigate floods-droughts issues. Geomatics tools, technologies application are under investigation by the group of researchers for farmlands sustainability improvement.

Keywords: Flood-MAR; geomatics; contour-strip; sustainability; farming.

1 Introduction

Flood and droughts are becoming complicated issues worldwide with accelerated climate change (Adenova et al. 2023). The proper flood-drought mitigation strategies with the proper technologies, including Geomatics, will be promising to expand in the practical applications in Kazakhstan, CA regions. Some countries started to apply more Flood-MAR programs. Historically California constructed many structures to control water movement with big dams, reservoirs for intensive surface and groundwater use. These days, California is moving toward a more sustainable approach by restoring the natural water movement system by replenishing its underground water resources. California expands the community farmer-based user-friendly Flood-MAR Hub (Flood-MAR 2023). Along with California, the Canada - US transboundary River Basin committee group of farmers also use the Flood-MAR strategy for flood-drought mitigation activities (RRBC 2023). Keller's group of researchers (Keller et al. 2000) analysed different strategies for water storage: water in soil profiles, subterranean aquifers, small reservoirs (ponds), and big reservoirs with dams. Storing water in underground aquifers is recommended as the sustainable approach: water can be stored for years, with little or no evaporation loss; can be used in drought years; can be near or directly under the point of use; can be immediately available through pumping. Conjunctive use of groundwater and connected chains of ponds with groundwater recharge are generally the best systems for flood-drought mitigation and water sustainability programs (Keller et al. 2000). Another great advantage of groundwater is that as water slowly percolates down into the aquifer, it is usually purified of biological pollutants. Thus, groundwater is usually the best source of drinking water, especially in rural areas of developing countries where water treatment facilities are not available. The critical issue facing many groundwater aquifers today is that the volume of water withdrawal exceeds long-term recharge, resulting in rapidly declining groundwater levels in many areas.

2 Materials and methods

Currently we are working on the German-Kazakh "Urbane water management: German experience for Kazakh cities" project (TERESA), supported by the German Federal Ministry of Education and Research (BMBF) under the CLIENT II Programme "International Partnerships for Sustainable Innovations" (TERESA 2024). The aim of the project is to learn the German experience with flood issues and mitigation programs and adapt the sustainable concepts for water management programs. This Includes analysing sustainable urban drainage systems (SUDS 2024) to reduce and to manage flooding using advanced simulation tools and applications of MAR and to increase the cross-seasonal water availability using web-based simulation tools (INOWAS 2004). The research group is targeted to expand this TERESA project adaptation for rural regions, for Kazakh's farmers with Geomatics applications for farm's sustainability.

Research questions within this Flood-MAR Geomatics applications effort: 1) Will it be possible to adapt the Flood-MAR approach to Kazakh farmers?; 2) How the contour-strip division of the farmer land catchment combined with the Flood-MAR would mitigate floods-droughts issues?; 3) What strategy, tools, technologies, should be used for these activities?

Effectiveness of various infiltration scenarios on the different soil types are under investigation based on local and regional water balance evaluations for SUDS and modified MAR efforts (Figure 1).

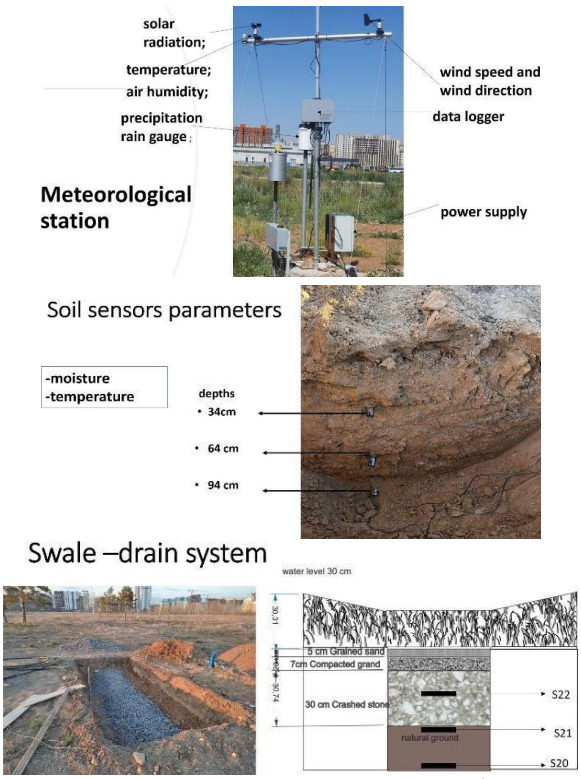

Figure 1. TERESA project INOWAS MAR research training polygon test site.

Within the TERESA project INOWAS MAR research training polygon test site facility is used for the research and training activities. With the promotion of the big international banks, big corporations, many developing countries focus mostly on modern capitalism in growth, in terms of the monetary value of aggregate goods and services, causes widespread ecological damage and is not necessary for the further increase of human living standards (D'Alisa et al. 2015). Degrowth theory with connections to the more natural friendly approach in development, is not popular and not supported by some of the developing countries (Hickel 2022). More aggressive natural resources extractions and agricultural land use are supported and subsidised in many countries (Horowitz 2023). Degrowth is an academic and social movement critical of the hegemony of economic growth perpetuated by capitalism. Degrowth initiates an equitable and democratically-led downscaling of production and consumption to achieve environmental sustainability, social justice and well-being (Bokat-Lindell 2021). The natural eco-friendly technologies are missing the proper support in Kazakhstan. Kazakh Government provides the financial subsidising support mostly to the big mining companies, big agrarian groups, which quite often extract resources, by destroying the natural wetlands, lakes, swamps. Kazakh people's efforts to preserve the natural system, swamps, and lakes are often ignored (Vigano 2022).

3 Results

We are working on promoting the Flood-MAR approach to Kazakh farmers', convincing the local farmers to adapt and apply more MAR combined with forest shelterbelts for snow water retention activities. A key element in this strategy is the optimal utilisation of the MAR method to address the persistent issue of drought on farmlands. By applying MAR, farmers can be more sustainable in drought seasons, and be more efficient in water resource management, by having more reliable solutions to alleviate irrigation water scarcity. KazGer farm, located in the North part of Kazakhstan, Akmola region, had shown interest in working with us on adaptation of the TERESA INOWAS MAR approach. Currently we are investigating and preparing KazGer farmlands for potential MAR applications combined with shelterbelts for snow water retention (Figure 2). On KazGer farmlands we are working on Geomatics applications, providing the geodesy topographic surveys to identify potential locations to set up the snow water retention lowest areas combined with MAR and shelterbelts. We need to provide the proper contour-strip division of the farmer land catchment combined with the flood-MAR; it should eventually work for the floods-droughts mitigation issues.

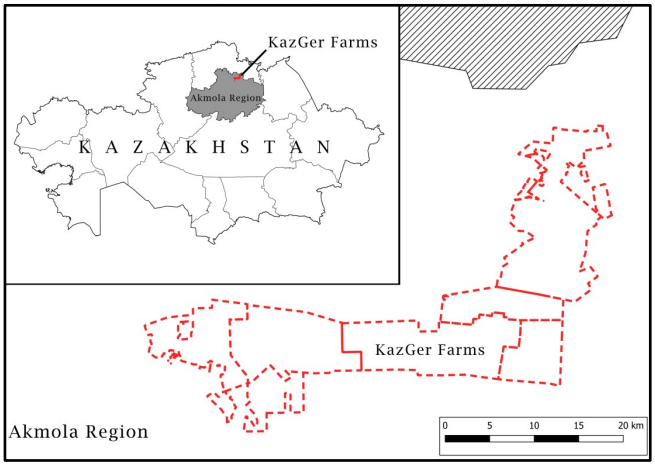

Figure 2. KazGER farmlands, located in the North Kazakhstan, Akmola region, shown in red to adapt the TERESA INOWAS Flood-MAR approach

4 Discussion

With Geomatics applications, we are working on the geodesy topographic surveys to delineate the proper contour-strip organisation of the farmland territory on the division of the catchment into several contour strips along horizontal lines. The main water-regulating structures are shafts combined with water-absorbing ditches filled with organic materials. We need to identify potential small pond locations with MAR to set up the snow water retention lowest areas combined with shelterbelts (Figure 3).

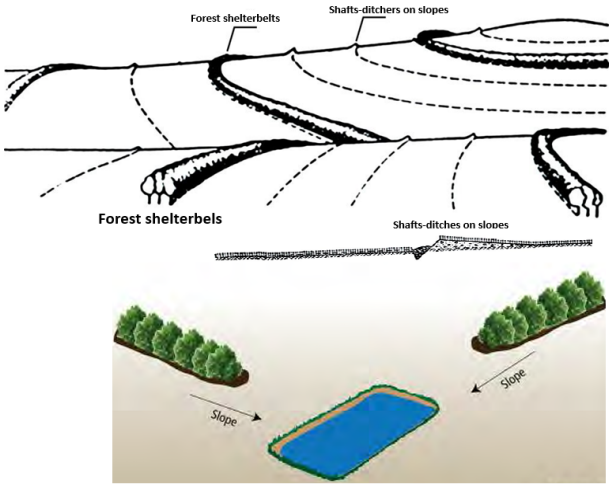

Figure 3. The contour-strip organisation of the farmland with shafts-ditches and small pond locations for MAR, adapted-modified from (Shelterbelts 2010).

5 Conclusions

Kazakhstan has many problems with disaster events, including floods and droughts. The most strategies that Kazakhstan has used are based mostly on the direct intervention in the natural water movement by building big dams, engineering constructions with settlements and development in the flood zones. The farmlands are also under intensive exploitation with mostly geometric shapes of farm plots: rectangular, without considering natural topography, terrain, to follow the water movement. The contour-strip organisation of the territory for the division of the catchment into several contour strips along horizontal lines combined with the Flood-MAR technologies should be a more sustainable approach to mitigate floods-droughts issues with reasonable financial expenses. Geomatics technologies and expertise are required to improve these types of programs for farm's sustainability.

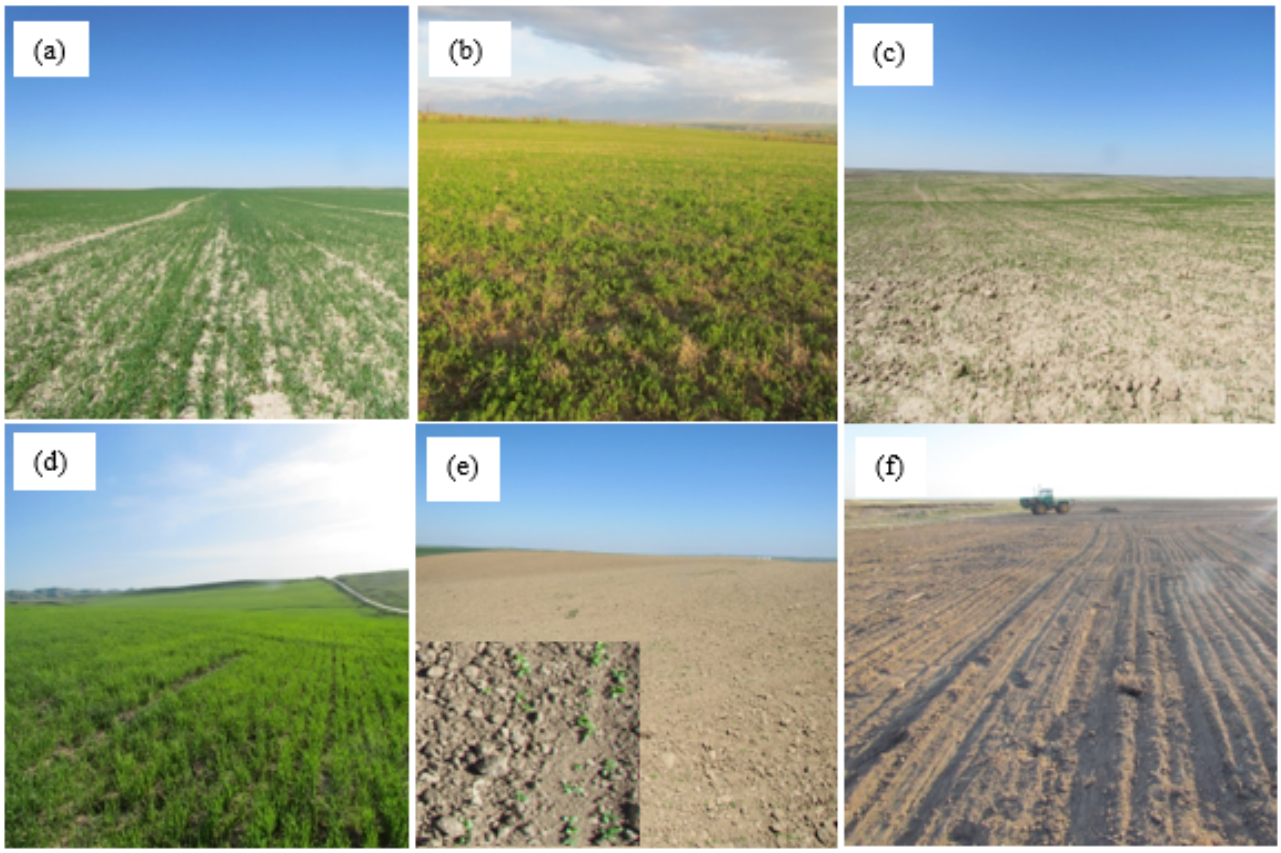

Figure 4. The preliminary survey of the farmland in the foothill zone: (a) winter wheat; (b) perennial alfalfa; (c) spring barley; (d) winter wheat (beginning of tillering); (e) safflower seedlings; (f) safflower cultivation and sowing, which requires the proper contour-strip organisation with shafts-ditches and potential pond locations that may work for water collection with MAR approach, combined with shelterbelts.

Our preliminary farmland investigations had shown that farmers do not have the proper contour-strip organisation of the farmland with shafts-ditches and potential pond locations which may work water collection with MAR approach, combined with shelterbelts (Figure 4). Farmers complained that it is necessary to improve the water collection system and set up the irrigation system properly.

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