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Future Challenge and Water Resources Management Strategy of Libya

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Abstract: One of the major issues that need to be addressed in order to further development in Libya is the water. Satisfying public water demand while simultaneously protecting the ecological support functions of freshwater systems will be one of the most critical and important challenges of the country's future. Water scarcity has spread rapidly in many areas of the country as population and consumption levels have increased against a fixed supply of renewable fresh water. This paper proposes a nationally formulated approach with a clearly defined strategy and hierarchy of objectives. In this article a clear definition of the national goal of the water resources strategy is given as "to significantly improve the living condition of the Libyan people in a sustainable manner". To carry out such water resources strategy there is a need to determine set of outputs that can contribute to this overall goal through the realisation of a timeframe of preparation period, a short-term goal and a long-term goal. It is also derive these strategic outputs from our analysis of the issues and problems that Libya has been facing. To ensure successful implementation of each output, it is suggested a set of activities encompassing physical, managerial, economic and institutional aspects. The output will advance the long-term goal of the water resources strategy, to maximise benefits through the sustainable management of water resources and in doing so, will contribute to the significant improvements in the Libyan living conditions.

Key words: Water resources management strategy in Libya

INTRODUCTION

Water resources are distributed unevenly on the Earth's surface. While the world as a whole may arguably have sufficient water to support its inhabitants, it is not equally the case for countries and regions everywhere. In Libya, lack of water resources is a common predicament and has become an increasing constraint on the country's economic development, particularly with respect to food production, the biggest water user. In an effort to make up for this shortfall, Libya has been exploiting its non-renewable fossil water, thereby depleting its resource base and undermining its long term economic development and food security.

Over the years, tremendous efforts have been made to combat water scarcity and increase food supply through irrigation [1]. Despite these efforts, however, the productivity resulting from irrigation in Libya remains low simply because of its scarce water resources. Moreover, there are limited possibilities for expansion of irrigation, so that the growth in the rate of food production has been unsustainable [2].

In contrast to disappointing food production, the growth of population and hence of food demand has been rapid in the country. As a result, an increasing portion of food supply has to rely on imports. Those imports have substituted for the water that would otherwise be needed for food production locally.

A growing scarcity of fresh water relative to human demands is now evident in Libya. Two of water's most fundamental functions - its role as a prerequisite for life, on the one hand and its use as a commodity or economic resource on the other - are increasingly in conflict. In many locations, extracting more fresh water for agriculture, industry or cities now places the sustainability at risk. Finding ways to satisfy human water demands while at the same time protecting the life-support functions of freshwater systems now ranks among the most critical and difficult challenges of the future. It is a challenge that spans science, technology, policy and politics and is one that demands new partnerships that cross disciplinary and professional boundaries.

Dimensions of Challenges: The geographical location of Libya in the arid region where more fresh water is needed

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to sustain the current national population of over five million is one of the biggest challenges for the future. Because rainfall is not sufficient and is limited to only the coastal areas, Libya is heavily dependent on groundwater resources. The clearest indicator of such unsustainable use is over-pumping of groundwater, a practice now widespread in many food-producing areas and large cities. For example, groundwater withdrawals exceed recharge levels throughout the Gefarah plain and throughout Nafusah/al-Hamada, both important food production areas.

Another sign of excessive of water use is that many major aquifers located in areas where irrigation water is most needed are now affected by sea-water intrusions. These include the area around the city of Tripoli in the north west of the country, where the shallow aquifers have already been extracted and the salt water has started to spread in many locations of the Gefarah Plain.

With many aquifers having been over-tapped to meet current water demands, stresses on fresh water systems will worsen markedly as population and consumption levels increase. Two major dimensions of the water-scarcity challenge stand out: (1) maintaining food security in the face of water constraints on agriculture and (2) preventing a downward spiral in the health of the aquatic environment.

With a high water deficit in northern part of Libya, the country is threatened by more pronounced shortage in the future in a way that could constrain economic development, food security and social stability, unless drastic measures are taken. In this regard, there is a need to address future challenges through local water management.

Water and Food Security: Food production is a very water-consumptive activity. Growing the food needed to feed the population in future could require an even larger volume of additional water will need to be extracted from groundwater systems if that water is to be delivered to farms and managed inefficiently. In the light of the future water-use, it will be difficult to supply this much additional water on a sustainable and ecologically sound basis.

In recent decades, as urban water demand increased, cities began to pull water away from agriculture. A portion of this greater urban demand will be met by transfer from agriculture. The manner in which this farm-to-city reallocation of water is managed could determine the nation's ability to feed itself.

In order to achieve food security, a policy of self-sufficiency is still popular. This excellent aim, however, is beyond reach with either the current or the foreseeable available water resources. The simplicity of the food-security policy contributes to the expansion of irrigation but does nothing to minimise food waste. Other possible ways of bridging the gap in food demand must be explored. For example, more reliance on food imports and sea food will certainly minimise the pressure on the water resources that have already been suffering depletion.

In addition, water use efficiency can be achieved by two groups of approaches. First, technical efficiency can be achieved by using more efficient technologies, such as drip irrigation instead of water spreading for irrigation or more efficient scheduling of water applications both by improvements in water distribution systems and the use of crop and soil sensing systems linked to computer-controlled water distribution. Domestic water use can also be made more efficient by installing more water efficient equipment to reduce the volume of water used per capita. These practices are sometimes called 'productive efficiency'.

A second form of water use efficiency is achieved via the application of principles to do with allocation. Applied to water, which in Libya is everywhere limited, this idea is simply expressed in the form of a question: which activity affords the best return on the use of water? The approach is relevant at the level of the farm, where the return on a high value crop for an international market would be more than that of another crop.

Groundwater Protection and Sustainability Development: National water consumption has already increased since the 1970s. To meet this rising demand, engineers have constructed several dams and many desalination plants, wastewater treatment plants and large transportation schemes. Since 1980, thousands of kilometres of pipes have been laid to transport groundwater between water basins. But while the government built these dams, desalination plants and the Man-made River pipelines to meet the legitimate goals of water supply, water engineering has failed to protect the groundwater basins from seawater intrusion in the coastal areas.

The primary destroyer of the northern basins is the drilling wells to mine the groundwater, a practice which causes the flow of salt water into these basins. These changes in turn impact on plant and soil and their interrelationships.

The Libyan society is thus faced with a monumental management problem. There are tens of billions of dollars worth of hydraulic infrastructure in place, which is literally killing the environment. Most notably, the groundwater around Tripoli city is to some degree at risk of seawater intrusion. The shallow groundwater aquifers have already been affected and as the wells are being deepened the intruding saltwater quickly makes contact with deep groundwater reservoirs.

The Aral Sea tragedy offers the most striking modern example of the interconnections between the environment and the economy. Moreover, there is a clear parallel with the present situation in Libya. As the mining of the groundwater continues in the coastal areas, the salt concentration of water in the shallow aquifers increases and the groundwater in deep aquifers is put in jeopardy. The cost and the risk of ignoring this spread of saltwater intrusion are rising [3].

As noted above, the aim of the extension of cropland is to achieve food security. This aim may indeed be achieved and some profits might be gained for a very short period. But in the long term it only will put great pressure on the groundwater aquifers, resulting in the destruction of the existing irrigated area. The consequences for both the environment and the economy will be serious.

Goals, Proposed Actions and Outputs: Meeting the water challenges in Libya for the future will require a nationally formulated approach with a clearly defined strategy and hierarchy of objectives. This approach involves formulating a strategic goal, as well as setting out purposes to contribute to that goal. To satisfy the goal, it should be recognised that other sectors must provide tangible benefits which contribute to the improvement of Libyan living standards.

The national goal can be defined as "to *improve significantly the living condition of the Libyan people in a sustainable manner".* Water resources strategy outputs can contribute to this overall goal through the realisation of a preparation period, a short-term goal and a long-term goal. These can be defined as follows:

Preparation Period: The devising of a comprehensive water resources strategy supported and managed by capable institutions, which provides tangible benefits to people in line with the fulfilment of basic needs.

Short-Term Goal: The implementation of a comprehensive water resources strategy, providing substantial benefits to people in fulfilment of their basic needs as well realisation of other benefits of water use in a sustainable manner.

Long-Term Goal: The maximisation of the sustainable benefits of water use in the country.

To achieve these goals, we suggest nine strategic outputs, as listed below:

- Functional, effective seawater intrusion management systems.
- Importation of high consumptive water crops.
- Adequate supply of and access to quality potable water for all inhabitants.
- Optimisation of economic uses of water by industry.
- Appropriate and efficient irrigation available for optimal use of irrigable land in a sustainable manner.
- Enhancement of water related data acquisition and information systems.
- Adequate legal framework functioning and adapted to changing circumstances.
- Regional/bilateral cooperation for mutual benefit.
- All institutions functioning effectively.

These strategic outputs have been derived from an analysis of the issues and problems that Libya has been facing. Each output requires the successful implementation of a set of activities encompassing physical, managerial, economic and institutional aspects. Below, each is categorised with reference to one of three water resources aspects:

- Security (Outputs 1 and 2)- security of water;
- Users (outputs 3 to 5) - types of water use (e.g. domestic water supply; industry and irrigation).
- Mechanisms (outputs 6 to 9) - mechanisms that enable the benefit of sustainable water use to be realised, enhanced and maximised. These mechanisms include regional cooperation, water-related information and metering systems, appropriate frameworks and appropriate institutional support.

Together, these outputs will advance the long-term goal of water resources strategy, to maximise benefits through sustainable water management of these resources and in doing so, will contribute to the significant improvement of Libyan living conditions. Table (1) summarises the strategic goal, purposes and outputs developed for various time frames.

Table 1: Summary of Strategy output

Goal			Living conditions of Libyan people significantly improved in a sustainable manner		
Time frame			3-Year Preparation period	5-year Strategy	10-Year Strategy
Purpose			Devising of comprehensive water resources strategy, supported and managed by capable institutions, to provide tangible benefits to people in line with the fulfilment of basic needs.	Implementation of comprehensive water resources strategy, providing substantial benefits to people in fulfilment of their basic needs as well realisation of other benefits of water use in sustainable manner.	Sustainable benefits of water use in the country maximised.
Outputs	Security	Groundwater protection	Institutional reformation for groundwater protection and management.	Effective measures adopted to manage groundwater extraction.	Effective groundwater management to prevent seawater intrusions.
		Food security	Institution authorised for trade agricultural products	Effective measures adopted to import crops.	High-consumptive water crops imported.
	Users	Municipal water supply	Planning for expansion of access to water supply and sanitation.	Increasing sanitation and drinking water coverage; service level and quality improved.	Adequate supply of and access to quality potable water for all inhabitants
		Industrial water supply	Economic activities for industrial water uses established.	Economic use of water and water bodies by industries enhanced.	Economic uses of water by industries optimised.
		Irrigation	Irrigation systems development and continuation for sustainable management,	Reliable irrigation service established on the basis of sustainability.	Appropriate and efficient irrigation available for optimal use of irrigable land in sustainable manner.
	Mechanisms	Information systems	Functional water-related system established.	Water-related system functioning.	Water-related information system enhanced.
		Policy and legal	Appropriate policy and legal framework, including equitable water use rights, established.	Adequate legal framework functioning	Adequate legal framework functioning and adapted to changing circumstances.
		Regional cooperation	Regional/bilateral cooperation framework normalised.	Effective mechanism for regional/bilateral cooperation functioning.	Regional/bilateral cooperation for mutual benefit achieved.
		Institutional mechanisms	Appropriate institutions established	Institutional mechanism for integrated management functioning.	All institutions functioning effectively

Effective Groundwater Management to Prevent Seawater Intrusions: Achieving the sustainable development of water resources is one of the most important challenges Libya is facing. Meeting the challenges require emphasising the development of the country's water resources from a holistic prospective that puts environmental considerations at the centre of Water Resources Strategy.

Activities:

- Prepare and implement a seawater intrusion management policy and plan.
- Conduct vulnerability mapping and zoning.
- Elaborate a monitoring system.
- Strengthen the problem networking and information system.
- Carry out community awareness/education programmes on seawater intrusion.
- Strengthen institutional capacity.

Indicators:

- By 2015, seawater intrusions are identified and located on district maps;
- By 2020, over-exploration of deep aquifers in coastal areas is forbidden;
- By 2030, no new extraction from all shallow aquifers in the affected areas.

The goal during the first three years is to enhance institutional capabilities for managing the seawater intrusion problem. To that end, the water authority will be designed as lead agency and given a clear mandate to implement output activities, including the seawater intrusion management policy and plan. The authority will be also responsible for coordinating efforts to reduce damage.

In the following five years, effective measures will be adopted to protect the affected shallow aquifers and assist local authorities in carrying out community awareness and education campaigns. The goal is to make the Libyan groundwater protection system fully functional and effective within ten years.

Importation of High Consumptive Water Crops: Due to the shortage of water resources in Libya, self-sufficiency in food is unachievable. Relying on other natural resources such as oil and gas that can be traded in exchange of food will give the country a certain degree of food security. We propose a number of actions to protect the local water resources from over-exploitation on the one hand and meet a large portion of the food requirement on the other.

Activities:

- Evaluate the food requirement per capita.
- Investment in agricultural projects in other countries that have a surplus of water.
- Investment in food manufacturing in Europe and other countries where oil and gas are exported.

Indicators:

- By 2015, the demand for food will be estimated;
- By 2020, a food import plan will be implemented;
- By 2030 all high water consumptive goods will be imported and an optimum of food security will be achieved.

Libyan external relations have recently witnessed a new era of diversity and openness to the world community. In the next three years, evaluation of high water consumptive crops can be made by the Agricultural Ministry. In the next five years the food import plan will be implemented and the flow of goods will take place. By the end of the year 2030, the output of investment in foreign countries will be paid back and food security will be realised.

Adequate Supply of and Access to Quality Potable Water for All Inhabitants: Drinking water is a basic human need. Every Libyan citizen should have reasonable access to quality potable water. However, since provision of adequate potable water is not enough by itself to ensure health, there should be widespread relevant education campaigns and access to appropriate sanitation facilities.

Activities:

- Enhance institutional capacity for coordination, planning, implementation and monitoring.
- Enact and enforce standards and regulatory mechanisms for water quality and effluent discharge.
- Improve management of urban water supply and sewerage systems.
- Maintain all installed wastewater treatment plants so as to achieve their capacities.
- Improve available desalination plants to their full capacities.
- Construct three new desalination plants of 100000m3/day each in areas of seawater intrusion.
- Adapt effective conservation and protection measures.
- Implementation of a metering and pricing system.

Indicators:

- By 2015, coverage of domestic water supply;
- By 2020, full coverage of domestic water supply;
- By the end of the year 2030, all wastewater will be treated;
- By 2030, 100% of inhabitants will have good quality water supply.

We propose a strategy to be adopted by the Water Council (WC) which gives priority to increasing water supply coverage throughout Libya, even if only at a basic level, over the next two years. Before this can be accomplished, it will be necessary to strengthen the institutional capacity for coordination, planning, implementation and monitoring. As a first step in this process, the Libyan Government should clearly redefine the respective roles of the various water authorities, including the General Water Authority (GWA), The Great Manmade River Project (GMRP), the General Water Supply and Sewage Company (GWSSC) and the General Environment Authority (GEA). We propose all these authorities should act under the umbrella of a National Water Council, acting as a department within it. The General Water Authority (GWA) will take the role of laying down overall water policies and will formulate national drinking water quality standards and regulations. Both the GWA and the GEA will assume responsibility for monitoring water quality to ensure that these standards are being met. The GMRP will concern itself with the groundwater supply. The GWSSC will take on the role of facilitator in

support of local institutions responsible for the implementation and management of water supply and sanitation services at district level.

In the following five years, full coverage of drinking water supply and sanitation will be provided at the same time as improvements are being made to existing services. Equitable cost-sharing mechanisms will be developed and implemented to maintain existing water supply schemes and ensure financing for expansion and improvement of these schemes.

Optimisation of Economic Uses of Water by Industry: In addition to guiding water use for domestic water supply and irrigation, the Water Resources Strategy will promote and enhance other uses of water that can provide business and employment benefits and/or improve the quality of life. Such uses should be compatible with existing water uses and future demand and should be sustainable and environmentally friendly.

Activities:

- Promote activities that do not depend on water.
- Support bottling of water for domestic use.
- Improve the efficiency of the industrial use of water.

Indicators:

- By 2015, action plan for industrial use of water resources prepared and approved and implementation initiated;
- By 2020, private sector investment substantially improved;
- By 2030, contribution to Gross Domestic Product (GDP) from industrial uses becomes significant and increasing over time;
- By 2030, opportunities for developing further uses indentified.

In the strategy's first three years, efforts will be made to identify opportunities for providing long-term benefits to Libya without compromising other types of water use and to establish mechanisms to support and control future water resources development. In the subsequent five years, investment in alternative water use projects is expected to come primarily from the private sector, subject to planning control over zoning and development design to protect Libya's interests. The new Water Council will work with other industrial authorities to develop a plan that will in turn improve the confidence level of private sector investors.

In the long-term, other economic uses of water should be enhanced to the point where they are significantly contributing to the national economy, based on Libyans' priorities.

Appropriate and Efficient Irrigation Available for Optimal Use of Irrigable Land in a Sustainable Manner: Access to irrigation is a critical factor in the maintenance of food security and is a key to food production on Libya's cultivable lands. Its national importance is reflected in the scale of investment devoted to the country's irrigation projects. In the last few decades, a huge part of the national development budget for infrastructure has been spent on irrigation. Despite government efforts to promote agricultural projects, however, the overall extent of agricultural production on much of Libya's land remains very low. In addition to problems associated with obtaining adequate cost contributions from the beneficiaries of irrigation projects, agricultural production typically suffers from low prices for many crops, poor market accessibility, difficulties associated with distribution and the declining trend in farming as an occupation. We propose a water strategy that sets out a number of activities which will improve the sustainability of the agricultural sector.

Activities:

- Getting general overview of the efficiency of the actual systems.
- Integrate irrigation planning and management with agricultural development.
- Improve management of existing irrigation systems.
- Improve planning and implementation of new irrigation systems.
- Improve groundwater management.

Indicators:

- By 2015, implement a plan to identify the most suitable and economic areas for agriculture;
- By 2020, there will be a focus on some of the agricultural areas that create wealth;
- By the end of 2030, optimal use of water in profitable land will be achieved in a sustainable manner.

For the first three years, we suggest a strategy that emphasises the implementation of efficient irrigation systems, focusing on projects that will enhance food security and rural employment and improve the prosperity of individual farmers and rural economies.

In the following five years, activities will be focused on achieving reliable irrigation services based on sustainability and the creation of wealth. By the end of the year 2030, appropriate and efficient irrigation will be available for optimal use of irrigable land in a sustainable manner.

Enhancement of Water-related Information Systems: Effective planning and water-related management depend on access to up-to-date and reliable data and a method of ensuring that this information is made available to users and institutions in an appropriate form and timely manner. Libya's present information systems need to be improved to support users in their effort to accurately assess water demands and available supplies. To improve this situation, we suggest the establishment of functional information collection and dissemination systems and the upgrading of data quality by strengthening the new Water Council and other institutions.

Activities:

- Improve information by setting up a reliable monitoring system collection and publishing mechanisms.
- Extend and upgrade the meteorological and groundwater monitoring network.
- Integrate the water resources database with the environmental database.

Indicators:

- By 2020 all meteorological stations well equipped;
- By 2020, satisfactory dissemination of water quality data achieved;
- By 2030, high level of satisfaction among the public and users of information systems achieved;

By 2030, the number of well-equipped meteorological stations increased to meet Libya's commitment to World Meteorological Organisation (WMO) standards.

With the guidance of the Water Council, existing data acquisition, collection and dissemination systems will be reviewed and upgraded, as necessary to improve data accuracy, consistency and reliability. Data and data products will be made available to users in a timely manner. Greater access to reliable, up-to-date information will assist in ensuring the efficient use of water.

Adequate Legal Framework Functioning and Adapted to Changing Circumstances: The legal framework for water use in Libya must address emerging issues such as water use rights and the need for improvement in the enforcement of laws and regulations.

Activities:

- Review existing water policy.
- Improve enforcement and regulations.
- Establish water use rights.

Indicators:

- By 2015, integrated national policy approved;
- By 2020, all water-related conflicts resolved; and
- By 2030, Full compliance with acts and regulations maintained.

Within the first three years, existing water policies and regulations will be reviewed and water use rights will be developed to allow the effective implementation of water-related developments. Communication with the general public regarding their water rights and obligations will be improved. In the following five years, regular monitoring and updating will be carried out to ensure that the legal framework continues to function satisfactorily. By the end of the year of 2030, mechanisms will be in place to ensure that legal frameworks are functioning and able to adapt to changing circumstances.

Regional/Bilateral Cooperation for Mutual Benefit: The cooperation of regional partners is essential to the successful development of Libya's groundwater resources potential. There is already cooperation with the Egyptian and Sudanese Governments regarding Libya's eastern groundwater basins on the one side and with Tunisia and Algeria regarding Libya's western groundwater basins on the other. To be successful, all countries must accept a nation's fundamental right to use its own water resources. Throughout the proposed strategy implementation period, Libya will continue to enhance good cooperation with its partners through governmental and non-governmental channels.

Activities:

- Understanding the water-related needs of neighbouring countries.
- Pursue confidence-building measures with neighbouring countries.
- Implement mutually beneficial development.

Indicators:

- By 2015, set up a programme with each of the neighbouring countries;
- By 2020, Libya will continue to ensure a good cooperation with its partners;
- Implement the groundwater monitoring programs.

In its first three years, the proposed strategy emphasises the need to develop and implement an improved framework for regional cooperation. Existing groundwater-sharing agreements will be monitored in conjunction with an effective mechanism for ensuring compliance. Libya will evaluate regional water use demands and will continue to explore appropriate treaty mechanisms for using water.

In the following five years, we anticipate that an effective framework will be found to facilitate regional cooperation. Expected benefits from this cooperation, such as groundwater monitoring, will be realised and any possible over-explorations of groundwater in neighbouring countries will be avoided. By the end of the year 2030, substantial mutual benefits will be achieved.

All Institutions Functioning Effectively: Traditionally, Libya's socialist centralised system of governance has sought primarily to satisfy the interests of all people en masse, rather than those of the country's producers, traders and consumers as distinct stakeholders. More recently, with the changes in the system, there has been a shift towards community participation and private sector involvement in decision-making. In response, a change is necessary in the way government institutions operate, as well as in the role played by non-government institutions. The lack of these changes has led to conflicts in relevant legislation and confusion regarding responsibility and accountability. Below we identify a number of activities intended to address this issue.

Activities:

- Strengthen the Water Council as a central planning/coordination agency.
- Re-organise and strengthen concerned government institutions.
- Promote and strengthen water management bodies at community level.
- Promote private sector participation.

Indicators:

- By 2015, Water Council designed and empowered to coordinate national level planning for the entire water sector;
- By 2020, rights and duties of all relevant institutions at all levels clearly defined and available and accountability demonstrated;
- By 2020, Water Council fulfilling new mandate, with adequate resources;
- By 2030, all water sector planning units functioning well by addressing water issues.

During the first three years, existing institutions will be assessed to determine their capabilities and identify the mechanisms that would allow them to function more effectively. Lead government agencies, non-governmental organisations, academic institutions and private entities will be promoted and strengthened so that they can take on greater responsibilities in water resources management and development. In particular, the General Water Authority (GWA) will be re-designed as the central planning and coordinating Water Council (WC). This council, in turn, will establish an information directorate that will collect, manage and disseminate information with other organisations on issues related to water resources and water use. Planning and implementation processes will be streamlined so that a greater percentage of sector funds reach the intended beneficiary institutions. In the subsequent five years, there will be increased emphasis on integrated water resources management, at both central and local levels. Within 10 years, all institutions will be functioning efficiently with the goal of maximising the benefits associated with sustainable water resources development.

CONCLUSIONS

Satisfying public water demands while simultaneously protecting the ecological support functions of freshwater systems will be one of the most difficult and important challenges of the country's future. Water scarcity has spread rapidly in many areas of the country as population and consumption levels have increased against a fixed supply of renewable fresh water.

- Meeting the challenges water scarcity poses to food production, environmental protection and political and social stability will require new approaches to using and managing water.
- Greater effort will be needed to reserve water for the maintenance of the environment and, where necessary, to return water to natural systems to restore their functions.
- Concerted efforts will also be needed to slow the growth in human demands for water.
- Creative new ways of obtaining both commodity and ecosystem benefits from the same volume of water will also be needed. Developing and implementing these options will require new partnerships and alliances that draw upon the expertise of professionals from many fields.

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