中华人民共和国水利部
The Ministry of Water Resources of the People's Republic China

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Swiss Agency for Development
and Cooperation SDC

气候变化下金沙江流域水资源与风险综合管理

Jinsha River Basin Integrated Water Resources and Risk Management under Changing Climate

2016.11

ORGANIZATIONS

长江水利委员会

Changjiang Water Resources Commission (CWRC)

长江水利委员会国际合作与技术局

Bureau of International Cooperation, Science & Technology (BICST)

长江水利委员会水文局

Bureau of Hydrology (BOH)

长江水利委员会长江科学院

Changjiang River Scientific Research Institute (CRSRI)

长江水利委员会长江勘测规划设计研究院

Changjiang Institute of Survey, Planning, Design and Research （CISPDR)

南京水利科学研究院

Nanjing Hydraulic Research Institute（NHRI)

水利部中国科学院水工程生态研究所

Institute of Hydroecology, WRM & CAS (IHWC)

中国科学院寒区旱区环境与工程研究所

Cold and Arid Regions Environmental and Engineering Research Institute (CAREERI)

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目录

Table of Content

1.背景 Background

Sino-Swiss

Sino-Swiss JRB Project

合作背景 Cooperation Background

合作背景

自1950年中瑞建交以来，两国一直保持着良好的双边合作关系。2007年，中国和瑞士签订了备忘录，致力于加强高层次政治对话并扩大双边合作的领域。

近10年来，中瑞两国在水资源管理、防洪减灾、气候变化等领域有着广泛的合作。2009年，为了进一步加强水资源管理领域的科技合作，水利部与瑞士联邦环境、交通、能源和信息部签署了《中华人民共和国水利部与瑞士联邦环境、交通、能源和信息部合作协议》。

中瑞两国的科研人员认识到气候变化对社会经济发展的深刻影响，两国决定加强在气候变化及其应对措施研究的合作。在中国水利部和瑞士发展署的努力下，于2015年正式启动合作项目“气候变化下金沙江流域水资源与风险综合管理”。该项目旨在提高金沙江流域水资源综合管理水平及应对气候变化的能力，并为其他流域提供参考和借鉴。

Cooperation Background

Switzerland and the People's Republic of China have maintained bilateral relations since 1950. In 2007, Switzerland and China signed a Memorandum of understanding (MoU) to intensify high-level political consultations and strengthen bilateral dialogues across a wide range of areas.

Switzerland and China have been cooperating for over ten years in the areas of water management, flood protection and climate change. In 2009 they formalized the cooperation and signed a MoU on water management and hazard prevention.

By recognizing that Switzerland and China are significantly affected by the impacts of climate change on the water resources, they extended their cooperation in this area.

In this Context, the joint project ***Jinsha River Basin Integrated Water Resources and Risk Management under Changing Climate*** has been approved by MWRC and SDC in order to improve the integrated water resources management.

中瑞签署水资源领域合作同意书
Signature of Letter of Agreement Between China and Switzerland on Water Management

Sino-Swiss JRB Project

研究区域 Study Area

研究区域

金沙江是长江的上游河段，起源于青藏高原，自西向东流向喜马拉雅山脉底部的四川盆地，经青海，云南，四川，贵州和西藏五个省/自治州。流域的总面积约为54万平方公里，地理范围为90°23'-104°37'E, 24°28'-35°46'N。

气候变化及其伴随的冰川变化对水循环过程有着深刻的影响。近二、三十年间，金沙江流域水旱灾害事件呈频发的态势，给流域造成了极大的社会经济损失。因此，分析气候变化的影响、预测未来水文气象的变化趋势以及提出合理的适应性措施是实现金沙江流域社会经济可持续发展的关键。

中瑞合作项目"气候变化下金沙江流域水资源与风险管理"（JRB项目）旨在提高流域水资源综合管理的水平，从而实现气候变化下的流域可持续发展。

Study Area

Jinsha River is the upstream of Yangtze River, stretching from the Qinghai-Tibetan plateau in the west to lowland region in Sichuan Province at the Eastern edge of the Himalaya range. The Basin covers an extent from 90°23' E to 104°37'E and 24°28'N to 35°46'N,with an area of 540'000 km^2 . It crosses five provinces/autonomous region, namely, Qinghai, Yunnan, Sichuan, Guizhou and Tibet.

The local water regime is greatly influenced by glacier and climatic variability. In the last 2-3 decades, the region has experienced increasing extreme events (primarily drought and floods in the tributary catchments) causing significant economic loss. An overview of climate change impact and a thorough planning of adaption measures are essential for the long-term development of JRB.

The Sino-Swiss project, ***Jinsha River Basin Integrated Water Resources and Risk Management under Changing Climate （called JRB project）*** aims to improve the integrated water resources management, therefore to build capacities for adapting to climate change and socio-economic development.

流域特征 Basin Characteristics

- **高程跨度大，地形极为复杂**

Large elevation difference and variable topography

金沙江流域南北跨纬度11度，东西跨经度14度。地形极为复杂，众多高山深谷相间并列，峰谷高差可达4000米。

The basin crosses 14 longitudes and 11 latitudes with highly variable topography. High mountains and low valleys are radically distributed. The elevation difference is over 4’000 m.

- **气候时空变化大，垂直差异显著**

Spatial and temporal variability in Climate

流域主要有四种气候特征。从北向南分别是：高原亚寒半干燥气候、高原亚寒湿润气候、高原温湿润气候和温带气候。

From north to south, the watershed can be divided into 4 climate zones: the plateau sub-frigid and sub-arid climate zone, the plateau sub-frigid and humid climate zone, the plateau warm humid climate zone, and the warm temperature climate zone.

- **降雨分布不均**

Precipitation Variability

金沙江流域多年平均年降水量约710毫米；下河段两侧山地年降水量约为900至1300毫米。中上游属高山峡谷区，降水垂直分布明显，两岸山地年降水量为600至800毫米，而河谷地区年降水量仅为400至600毫米。

The yearly average precipitation in JRB is about 710 mm. The annual precipitation in lower part is about 900-1300 mm. For middle and upper parts, the precipitation shows a significant vertical distribution. The annual precipitation in hilly area is about 600-800 mm while 400-600 mm in valleys .

- **气候变化敏感区**

Sensitive to Climate Change

气候变化对长江源区的冰川和融雪径流具有较大的影响。此外，气候变化也会改变金沙江流域的特征。

Climate change has significant impact on glacier and snow melt runoff in headwater region of Yangtze River basin. The basin characteristics of JRB have changed due to climate change as well.

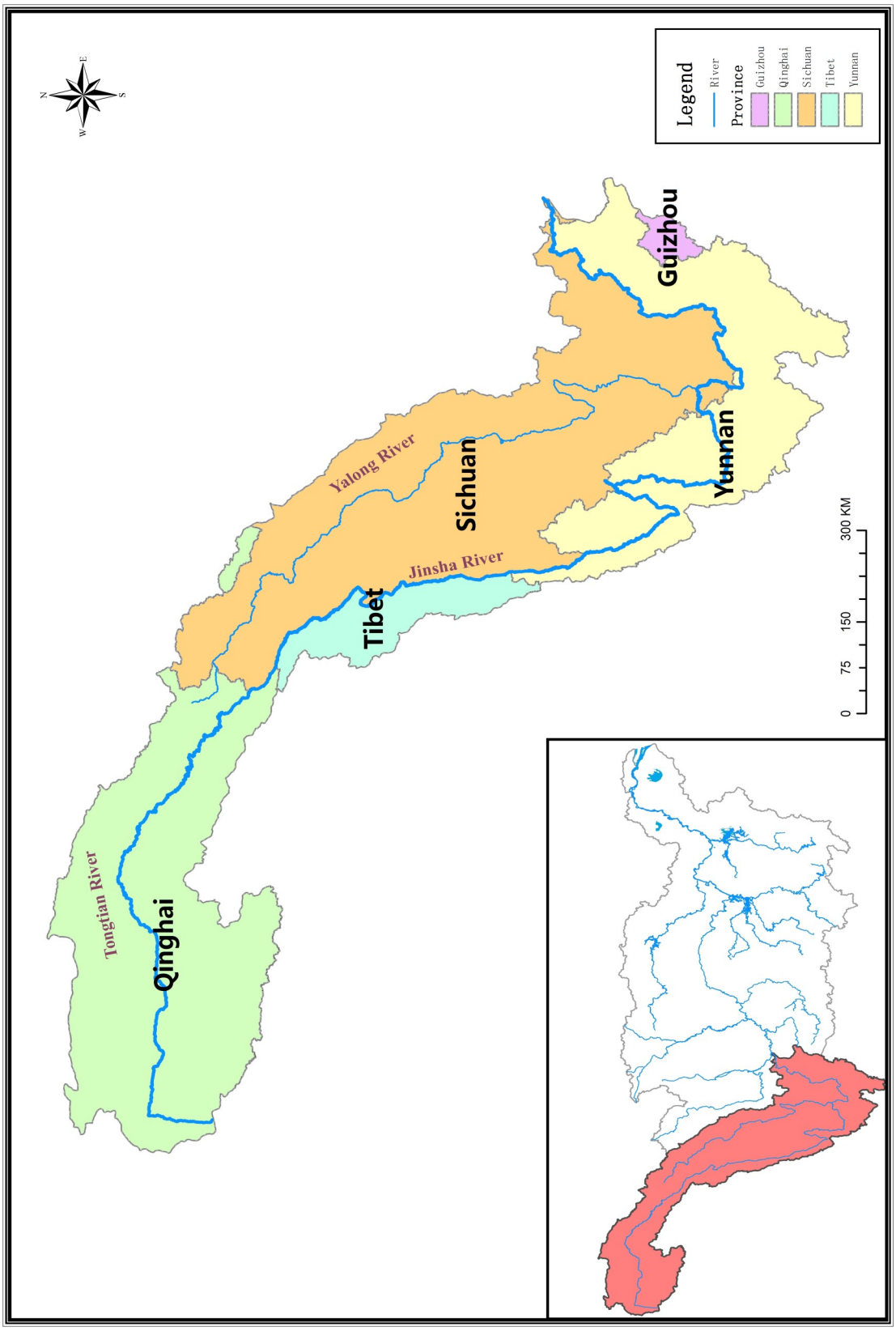
- **生物多样性**

Biological Diversity

金沙江流域是欧亚大陆生物群落最富集的地区。不到0.4%的国土面积上，分布着全国20%以上的高等植物和全国25%的动物种数。

Many Eurasia biological communities live in JRB. More than 20% of advanced plants and 25% of animal species in China are distributed in this region

研究区域地图 Study Area Map



Sino-Swiss JRB Project

背景 Background

丽江试点区 Pilot Region Lijiang Municipality

丽江 Lijiang

中瑞金沙江项目组与云南省水利厅、丽江市政府、丽江市水利局等部门紧密合作。项目组重点研究了丽江市水资源供需现状及未来变化趋势，为水资源优化管理提供了基础。

The Sino-Swiss JRB project team has cooperated with Bureau of Water Resources of Yunnan Province, Lijiang Government and Bureau of Water Resources of Lijiang. Lijiang Municipality (called Lijiang), as a pilot region, its current water demand-supply situations and their trends has been analyzed. This analysis provide a basis for further improving water resources management.

丽江市概要

丽江市地处云南省的西北部东经 99°23′ 至101°33′，北纬25°59′ 至27°56′。全市面积约为20549平方公里，其中92.3%的地区为山区。金沙江的中游河段由北向南流经丽江市。丽江市属于亚热带气候，受南亚/印度季风的影响。全市多年平均气温为13.6 □。

1997年丽江古城区被联合国教科文组织列为世界遗产。古老的建筑每年吸引着来自世界各地的游客。27个少数民族在丽江和睦生活，民族多样性和包容性也让丽江成为了体验少数民族风情的人文胜地。

General Information

Lijiang is located in the northwest part of Yunnan Province. With a total area of 20,549 km^2, Lijiang spans a range from 99°23' to 101°33' E and 25°59' to 27°56' N. Most of the area (92.3%) is covered by mountains. The middle reach of Jinsha River flows through Lijiang from north to south. Lijiang has a subtropical climate influenced by the South Asia/ India monsoon. The average annual temperature is 13.6 °C.

The old town of Lijiang has been recognized as a UNESCO World Heritage Site (UNESCO, 1997). The ancient buildings and water veins have attracted tourists from all over the world. 27 ethnic groups live in Lijiang. The ethnic diversity makes Lijiang a scenic spot of minority cultures and customs.

水资源危机 Water Resources Crisis

气候变化以及人类的社会经济活动加剧了丽江市的水危机:

The water crisis in Lijiang is triggered by the climate change and socio-economic development:

- 近30年来，玉龙雪山的雪线持续消退，冰川不断萎缩。

Yulong mountain Snowline continuously declined in past 30 years.

- 黑龙潭泉群曾是丽江古城主要的供水水源，自2012年以来，出现断流。

Spring water from Heilongtan (Black Dragon pond), which has historically been the main water supply source for Lijiang old town. It has dried up since 2012.

- 随着社会经济快速发展，需水量不断增加，供水量无法满足需求。

With the continuous increase of water demand there is a concern that the available water supply will not be able to meet the required demands.

2. 项目目标、任务与安排

Objectives, Outcomes and Framework

Sino-Swiss

总体目标

“中瑞合作金沙江项目”旨在的综合考虑气候变化和社会经济发展对流域水资源的影响，提高长江上游金沙江流域的水资源和风险管理水平，提出气候变化背景下流域水资源管理适应性对策和防灾减灾措施，确定试点流域水资源综合管理模式，为金沙江流域的经济社会可持续发展做出贡献。

Overall Objectives

The overall objective of the Jinsha River Basin (JRB) project is to foster integrated water resource management (IWRM), under the perspective of climate change and socio-economic and demographic development.

The IWRM shall meet the strategic development needs of CWRC, being effective in protecting life and assets, ensuring water severity of the region, and to a source of learning for global climate change.

金沙江 Jinsha River

项目内容/预期成果

预期成果1 Expected Outcome 1

揭示金沙江流域气象水文演变规律，为流域综合管理提供技术支撑。

The Outcome 1 framework consists of the development and consolidation of the hydro-meteorological knowledge on water dynamics aiming to improve water resources management in JRB.

预期成果2 Expected Outcome 2

识别气候变化对于金沙江流域水资源、极端水文事件的影响。

The main objectives of outcome 2 is to identify and further analysis the impacts of climate change on water resources and extreme events.

预期成果3 Expected Outcome 3

从风险管理的视角，综合考虑水资源管理、水旱灾害防治等方面的因素，提出应对气候变化的适应性措施及策略。

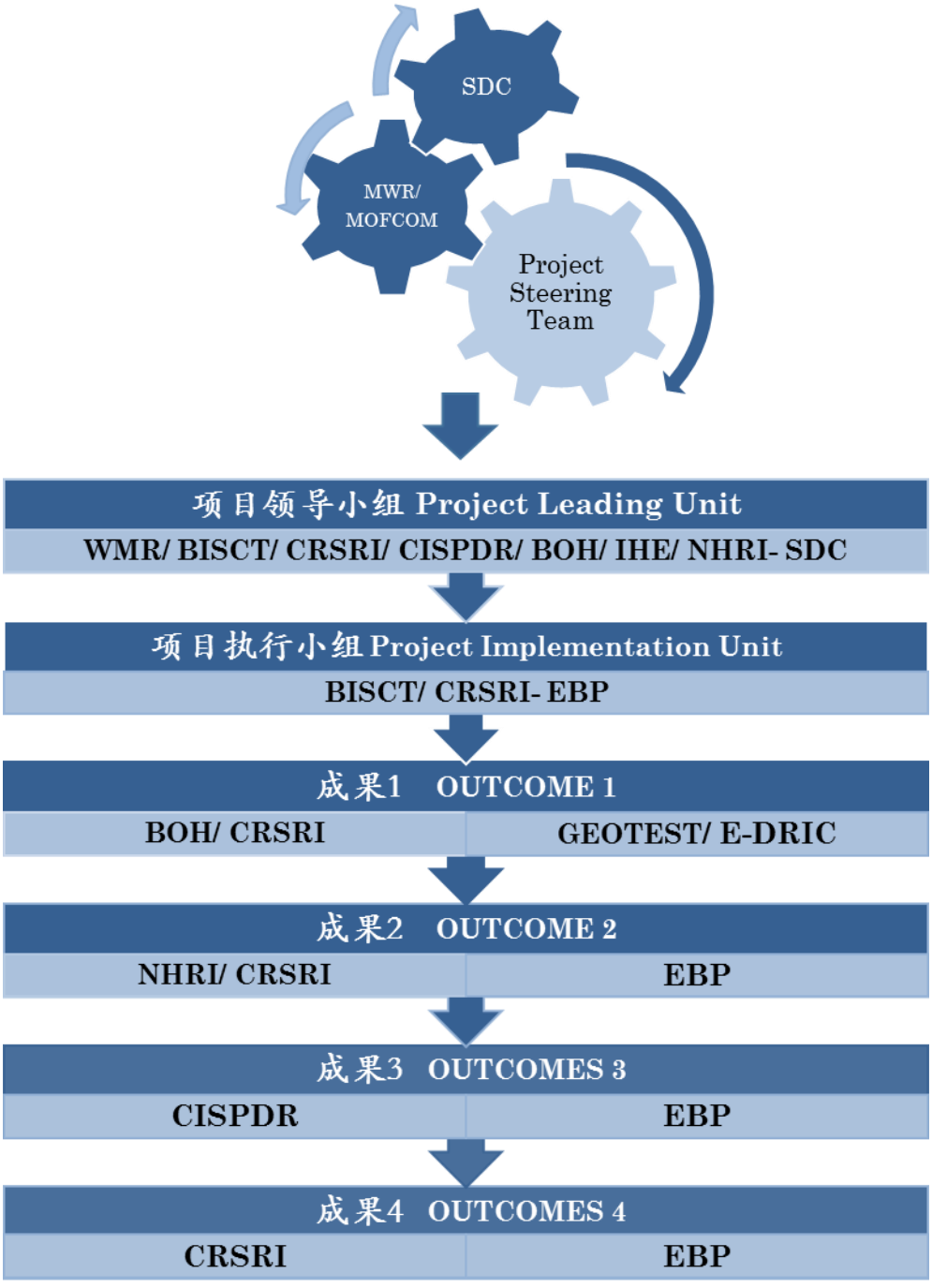
Adaptation strategies and measures to climate change for water resources and flood control and drought relief based on risk management are developed and assessed, including but not limited to cascade reservoir operation and management

预期成果4 Expected Outcome 4

构建信息平台，交流和共享水资源综合管理和气候变化适应性对策

An international platform for knowledge and expertise exchange on water resources management and climate change adaptation that discusses on going work and draws out lessons and understanding relevant to efforts to adapt to climate change elsewhere in the world is operating involving Swiss and Chinese experts.

项目安排
Project Framework



3. 进展与成果
Progress and Highlights

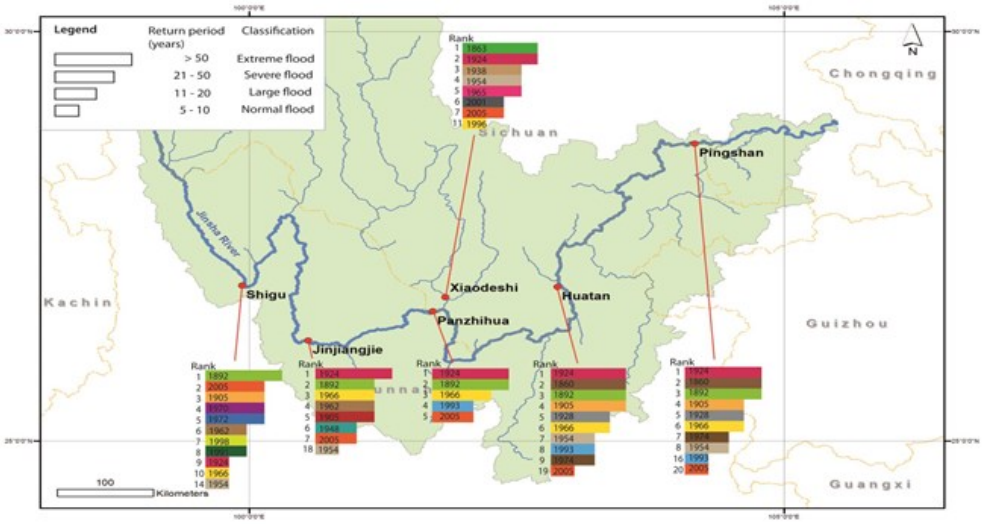
Sino-Swiss

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

识别气候变化下气象水文要素历史演变特征

为明晰金沙江流域在不同气候条件下的水文气象特征，研究基于历史观测数据，识别气候变化下降水、径流等关键水循环要素的历史演变特征，揭示气候变化对金沙江流域水循环过程的影响。



Hydro-meteorological characteristics under different climate conditions are recognized

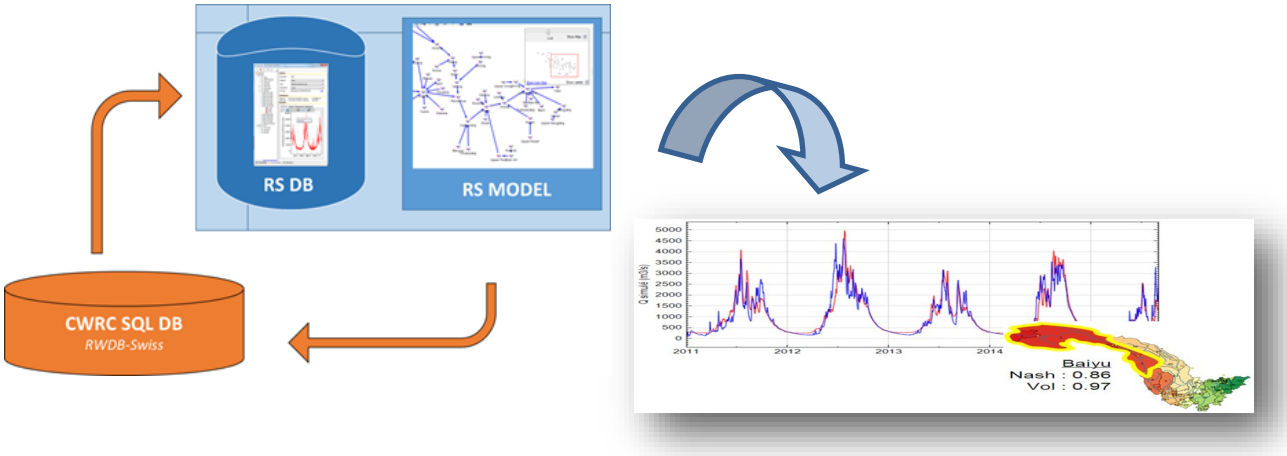
The preliminary impact assessment of climate change on precipitation and runoff, based on historical and climate change data, contribute to a better understanding of the hydro-meteorological characteristics and future trends in JRB. The results could be valuable reference for demonstrating climate change impact on socio-economic development to the public, and generate a vital basis for suitable adaptation measures.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

构建长-中-短水文预报模型，实现水文要素多时间尺度滚动预报

为提高金沙江流域水文预报能力，研究开发了适用于金沙江流域的长－中－短期水文预报模型 (HMFM)，可实现不同时间尺度的水文滚动预报。该模型已纳入了长江委现有的水文预报系统，为防汛工作提供了技术支撑。



Hydro-meteorological forecasting model contributes to runoff prediction and flood prevention of CWRC

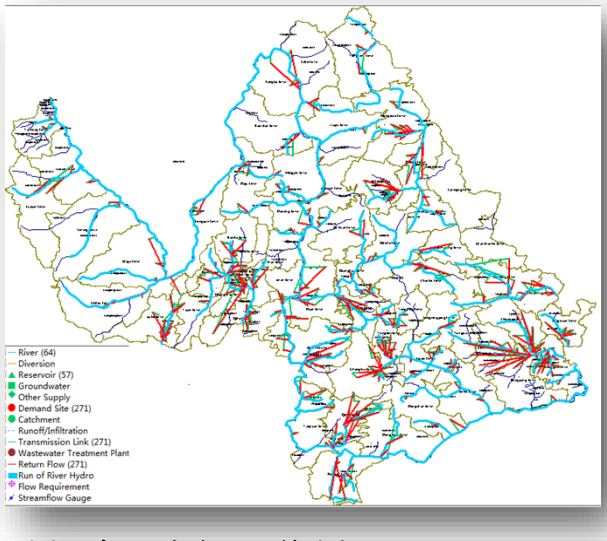
A hydro-meteorological forecasting model at long, middle and short term has been built and calibrated for JRB region. It has been incorporated into the existing hydro-meteorological forecasting system of CWRC. The results can provide data reference and decision basis for CWRC to command flood prevention, and hence enhancing the capability on runoff prediction and flood prevention management of CWRC.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

应用水资源评价技术，提高了丽江试点地区的水资源综合管理水平

为揭示丽江市水资源供需关系，研究建立了丽江市水资源评价和规划模型（WEAP模型），模拟并评价现状条件下水资源供需状况、识别气候变化对丽江市水资源供需关系的影响，明晰未来气候变化下水资源供需的发展趋势及面临的问题。



试点区域丽江市的WEAP模型界面
Features of WEAP Model (Water Evaluation and Planning System) for Lijiang Pilot Region

The application of WEAP improved the level of comprehensive water resources management in Lijiang pilot region

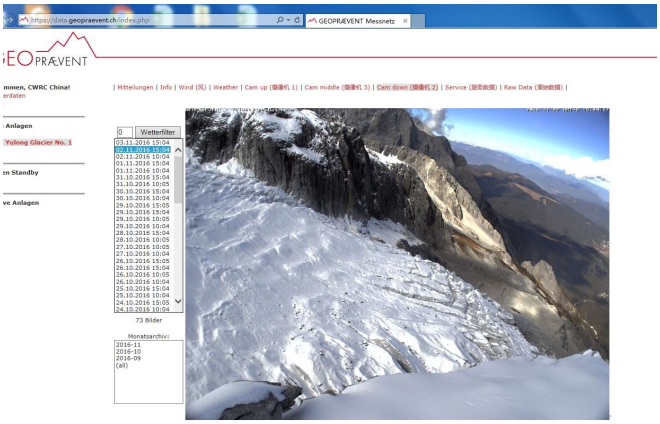
A Water Evaluation And Planning model (WEAP model) was built and calibrated for Lijiang City. The water supply and consumption status in Lijiang was reproduced, which provides an important fundamental basis for the future water resources planning. Furthermore, CWRC plans to promote this model to Lijiang Water Resources Department by training local technicians. This shall lead to the application of this model in daily management of water supply and consumption in Lijiang, and improves the level of comprehensive water resources management.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

提高玉龙雪山的冰川监测能力，进一步认识气候变化的影响

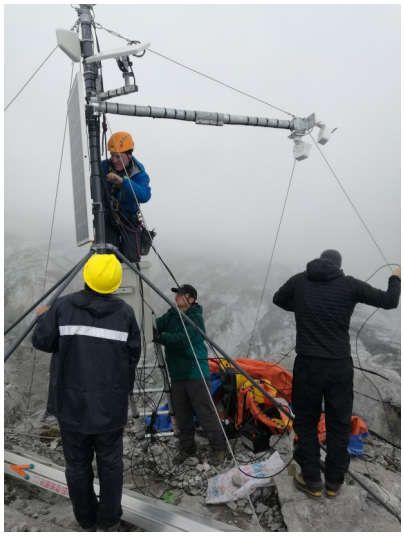
为提高玉龙雪山的冰川监测能力，对现有的监测设备进行改造和升级，可对冰川的时空变化过程进行实时自动化监测；基于监测数据，认识以增温为主要特征的气候变化所带来的影响。



玉龙雪山在线观测数据库
Online monitoring database for Yulong Mountain

Glacier monitoring capability in Yulong Snow Mountain has been improved

To improve detection capability of climate change, the enhanced monitoring equipment for Yulong Snow Mountain was designed and installed. After the automatic glacier monitoring station is under operation, it can greatly reduce manual measurement workload and improve monitoring efficiency. Furthermore, it will be vital tool for the research team to record glacier change.



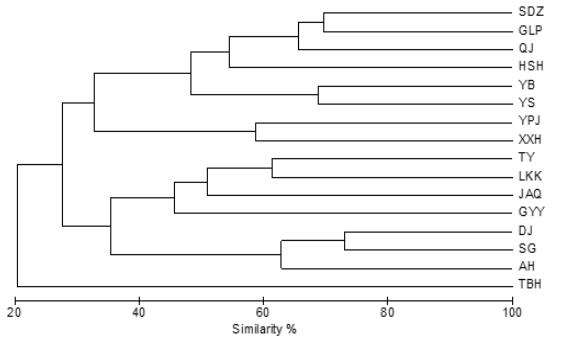
玉龙雪山地面监测设备
Glacier monitoring equipment

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

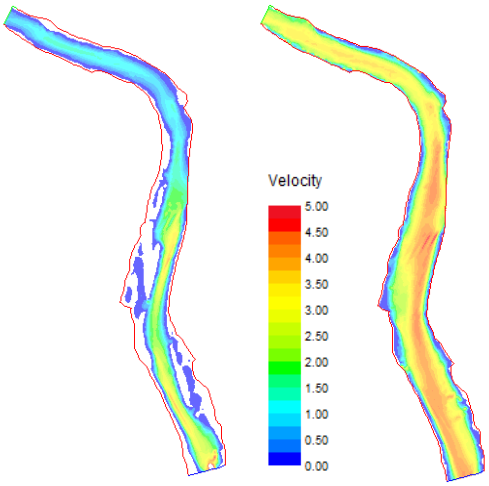
评价水生生态现状，构建敏感鱼类生境偏好曲线

为识别气候变化对水生生态系统的影响，研究系统分析了金沙江石鼓到宜宾段的水生生物多样性，评估水生生态系统的健康状况，建立了敏感鱼类生境偏好曲线以及重要鱼类栖息地攀枝花段的二维水动力学模型。



金沙江中下游鱼群聚类分析
Cluster analysis of fish community structure in the middle and lower reaches of Jinsha River

The assessment of aquatic ecosystem in JRB has been completed



攀枝花段二维水动力模型
2D-hydraulic model in Panzhihua Reach

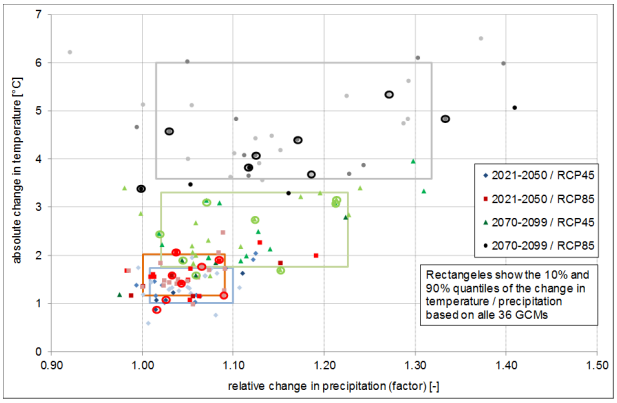
The composition, distribution and abundance of aquatic organism from Shigu to Yibin in JRB were evaluated. The endemic and protected fish resources and their important habitats were analysed. The heath of aquatic ecosystem in JRB was assessed by using the Fish Integrity Biological Index (F-IBI). The results indicate a strong need for ecosystem protection and restoration in study region. Furthermore, habitat suitability curves of sensitive fish species were set up and a 2D-hydraulic model of fish habitat in a Jinsha river section near Panzhihua were built and calibrated.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

构建流域水文模型，对比分析金沙江流域气候变化情景

为分析气候变化对水循环过程的影响，研究分析构建了RS 模型和VIC模型，对不同气候变化情景下水循环过程进行模拟，识别关键水文要素对于气候变化的敏感性，评判不同气候变化情景下金沙江流域水循环过程的差异。



气候情景的筛选

Selection of climate change scenarios

Comparison of hydro-meteorological models for climate change impact assessment has been conducted

Daily discharge calculated with two hydro-meteorological models – RS and VIC model - have been compared with measurements for the baseline period (1981 – 2010). It was shown that both models give good results for NASH / log NASH coefficient based on monthly data. However, the performance of RS model is better for daily data, especially in the Southern part of JRB (big study area). The same is true for results based on climate change scenarios for daily temperature and precipitation. Since reservoir management cannot be considered in VIC model, the Swiss and Chinese teams agreed to continue further impact assessment with RS model results.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

与当地水务部门加强交流与合作，了解气候变化对当地社会经济发展的影响

为深入了解气候变化对当地的影响，项目团队与云南省水利厅、丽江市政府、青海省水利厅、西藏那曲地区水利局等部门进行了多次调研，明晰当地水资源综合管理的需求及气候变化所造成的影响。

项目研讨会
Project Workshop

Informal discussions with local water authorities and got insight into impact of climate change on local region

The project team had several informal discussions with Water Resources Department of Yunnan Province, Municipal Government of Lijiang, Water Resources Department of Qinghai Province, Water Resources Department of Naqu Prefecture, Tibet, and more water related departments, to introduce the objectives, main work contents and expected results of JRB project to these departments. In these meetings, we listened carefully to their requirements for comprehensive water resources management and impacts of climate change.

Sino-Swiss JRB Project

进展与成果
Progress and Highlights

中方专家及技术人员的科研和技术水平得到了提高

为促进团队人员技术水平的提升，中瑞双方在气候变化、水文预报、冰川和遥感监测、水生生态和鱼类栖息地模拟、水资源综合管理等领域开展了多次交流，针对关键的科学和技术问题进行协同攻关，并建立了良好的合作关系。

Chinese technicians and experts capabilities have been strengthened

Through multiple trainings in Switzerland and exchanges with Swiss experts in China, the Chinese team of over 40 experts and technicians from 6 involved departments strengthened their capabilities on different levels. They not only studied Swiss advanced work ideas, but also updated professional knowledge on risks of climate change, hydro-meteorological forecasting, integrated water resources management, glacier and remote sensing monitoring, aquatic ecology and fish habitat simulation, and adaptability countermeasures, expanding the horizon of water resources management. This promoted the improvement of Chinese project team's overall capabilities and capacities.

学术交流及培训
Training and technical meeting

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