



# “The trouble”, its maker, and Yang Gui’s confidence in “taming the troublemaker” with a 1962 bilateral agreement

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## Abstract

On August 15, 1962, an agreement was signed by the representatives of the Red Flag Canal users from two counties in China. Since then, it has enabled people from both counties to share canal benefits, and as such ably become a cornerstone for a peaceful canal culture between the two peoples. The agreement and its making process were both initiated by Yang Gui (杨贵), the top leader of one of the two counties who masterminded the Red Flag Canal project. In explaining his motivation, Yang Gui stated, “We are building the Red Flag Canal for posterity; we must do everything we can to save posterity the trouble.” However, just *what* “the trouble” he perceived was, *who* the troublemaker he thought would be, and *why* he was confident that a bilateral agreement could serve the noble goal “to save posterity the trouble”, Yang Gui did not say, neither did he leave any record. In this article, we report our aspiration and endeavor to fill this knowledge gap, and present fresh discoveries and insights we derived from examining this instance through a CPR lens—an eclectic collection of economic constructs of common-pool resources (CPRs). The article is the fourth in a mini-series on the Red Flag Canal, one of the best kept secrets in the history of socio-ecological practice.

**Keywords** The Red Flag Canal · Yang Gui (杨贵) · Common-pool resources (CPRs) · Institutional arrangement · Elinor Ostrom · Irrigation canal systems · Pareto-efficiency · Moral guanxi practice · Socio-ecological practice · Ecopracticology

*We dedicate this article to Yang Gui [杨贵, (1928–2018)] who, for the people and land he loved, masterminded the Red Flag Canal project in the 1960s and improvised the 1962 agreement.*

Our use of the phrase “taming the troublemaker” in the article title is inspired by the title of a 2019 romance by American author Kadie Scott (Scott 2019).

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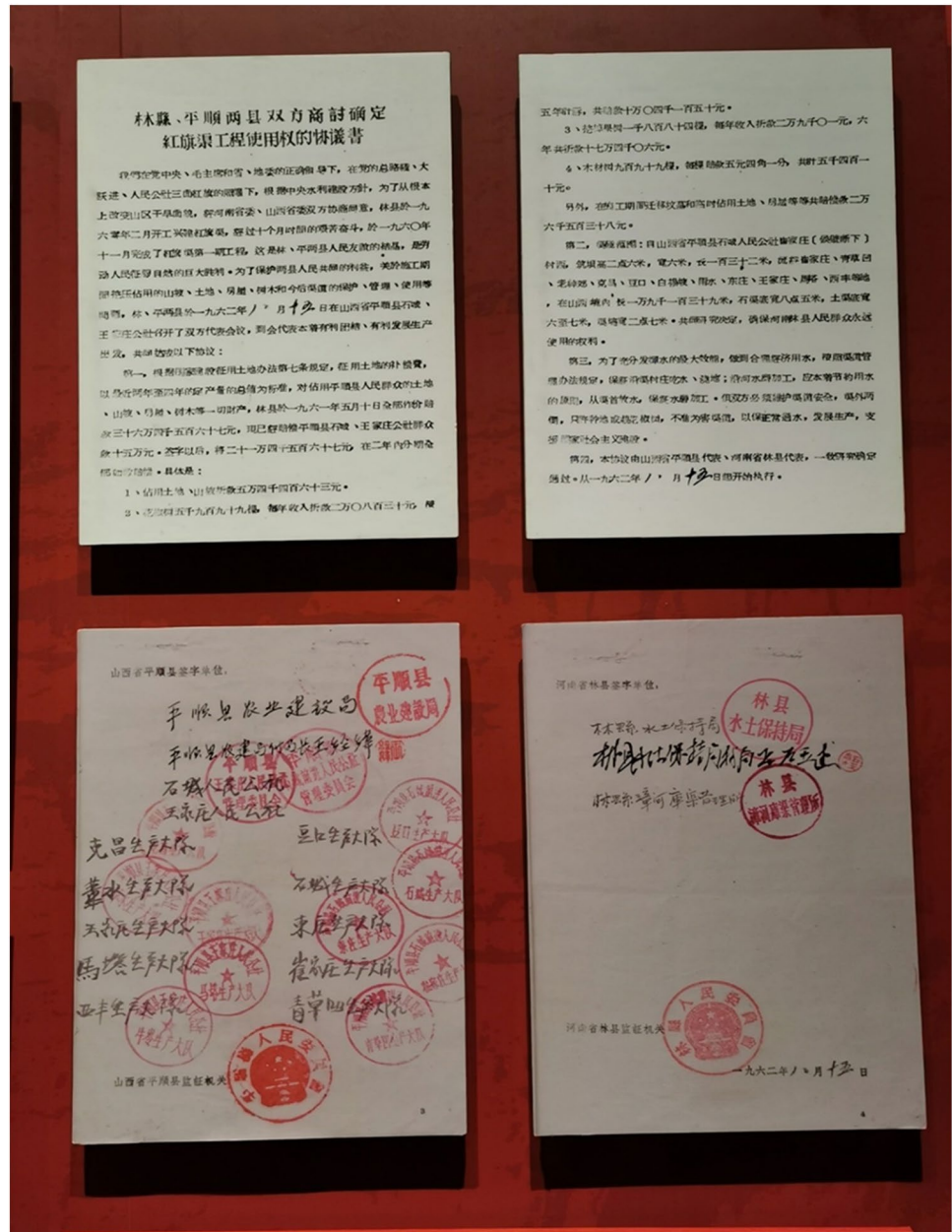
## 1 A 1962 bilateral agreement

In the Red Flag Canal Museum in Linzhou City [林州, formerly Linxian County (林县)], Henan Province, China, there is a replica of a 1962 agreement (Fig. 1).<sup>1</sup> The agreement was reached between two counties in different provinces: the then Linxian County in Henan Province and its neighbor Pingshun County (平顺县) in Shanxi Province. It was ratified by 15 governmental agencies from the two counties and notarized by their respective county legislatures (see the red stamps on the two bottom pages of the replicate in Fig. 1).

The bilateral agreement addresses issues key to the construction, operation, and management of the Pingshun segment of the Red Flag Canal. As shown in the dashed line box in Fig. 2, the Pingshun segment is the first 19-km section of the Red Flag Canal through which water from

<sup>1</sup> On January 24<sup>th</sup>, 1994, Linxian County became Linzhou City [Hao et al. 2011, p.393]. In the literature about the history of the Red Flag Canal, however, authors continue using the historical name “Linxian County”. Like the other articles in the mini-series on the canal (i.e., Chen & Xiang 2020a, b; Xiang 2020a), this article follows that convention for consistency and uses the present name “Linzhou City” only when necessary.

**Fig. 1** A replica of the 1962 agreement between Linxian County and Pingshun County in the Red Flag Canal Museum in Linzhou City (taken in situ by Wei-Ning Xiang, July 14, 2019)

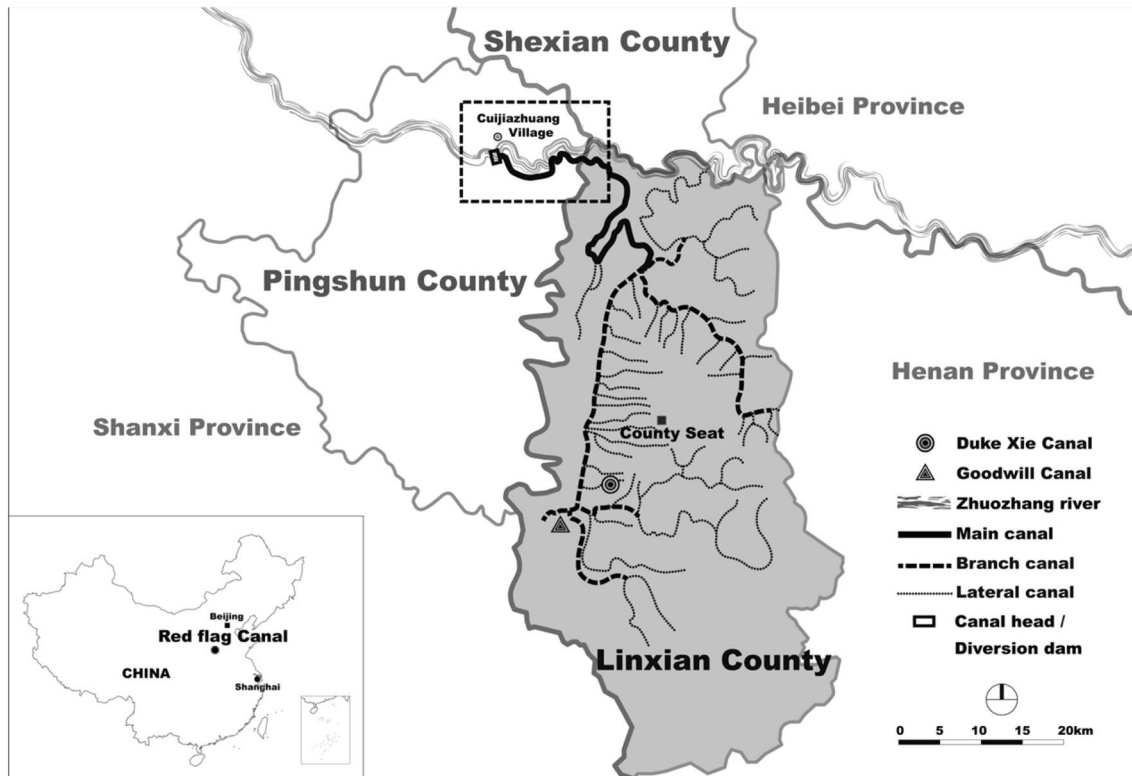


the Zhuozhang River (浊漳河) in Pingshun is diverted to Linxian [For the genesis of the canal—how it became a reality from serendipity and through impossibility, see Xiang (2020a)]. The agreement consists in four provisions<sup>2</sup>:

<sup>2</sup> The original Chinese text is “《林县、平顺两县双方商讨确定红旗渠工程使用权的协议书》(节选) 第一, 根据国家建设征用土地办法第七条规定, 征用土地的补偿费以最近两年至四年的定产量的总值为标准, 对占用平顺县人民群众的土地、山坡、房屋、树木等一切财产, 林县于一九六一年五月十日全部作价赔款三十六万四千五百六十七元, 现已经赔偿平顺县石城、王家庄公社群众十五万元。签字以后, 将二十一万四千五百六十七元, 在二年内分期全部如数赔偿。…… 第二, 渠线范围: 自山西省平顺县石城人

Footnote 2 (continued)

民公社崔家庄(侯壁断下)村西, 筑坝高二点六米、宽六米、长一百三十二米, (渠线) 流经…… 在山西境内长一万九千一百三十九米, 石渠底宽八点五米, 土渠底宽六至七米, 渠墙宽二点七米。共同研究决定, 确保河南省林县人民群众永远使用的权利。第三, 为了充分发挥水的最大效能, 做到合理经济用水, 按照渠道管理办法规定, 保证沿渠村庄吃水、浇地; 沿河水磨加工, 应本着节约用水原则, 从渠首放水, 保证水磨加工。但双方必须维护渠道安全, 渠外两侧, 只许种地或栽花椒树, 不准危害渠道, 以保证正常通水, 发展生产, 支援国家社会主义建设。” (Shen 2020, pp.120–122) The English translation and titles of provisions I, II, and IV are from Chen & Xiang (2020a, pp.334–335) with some adjustments by the authors of this article. Provision “2. The right to use canal water” in the 2020 translation (Ibid., p.335) was split into provisions II and III so that the two main points it contains stand out more.



**Fig. 2** The Red Flag Canal and its first 19-km Pingshun segment (in the dashed line box) [Chen & Xiang 2020a, p. 330]

1. *A permanent easement*<sup>3</sup> The canal's diversion dam is located on the Zhuozhang River near Cuijiazhuang Village (崔家庄村) in Pingshun County; From this diversion point, the canal extends to Linxian County through a 19-kilometer-long, 8-meter-wide swath of land in Pingshun County; Both counties agree that Linxian County has the permanent privilege to use this swath of land for the canal purpose.
2. *The right to use canal water* to make the most economical use of the canal water, villages along the Pingshun segment are entitled and guaranteed to use the canal water for drinking, irrigation, and powering water mills.
3. *A shared canal stewardship* both counties have the obligation to maintain the normal operations and safety of this canal segment.
4. *A compensation payout* Linxian County will pay Pingshun County, in installments, a total of 364,567 yuan to compensate the villages along the Pingshun segment for their loss of land and properties to the construction of the canal. This total amount was based on a valuation done by Linxian County on May 10, 1961. The first installment, 150,000 yuan, has been paid. The remaining installments will be paid off in two years from this signing date.

<sup>3</sup> The Chinese concepts of easement (地役权), including water diversion easement (导水地役权), were established 45 years later in the Property Law of the People's Republic of China. Passed at the National People's Congress on March 6, 2007, the Property Law came into effect on October 1 the same year (Chen & Xiang 2020a, p.334). The term easement is used here to help readers to appreciate the historical significance of this provision through the lens of a contemporary concept. This is clearly an example of moral improvisation in which practitioners circumspectly exercised *ecophronesis*—ecological practical wisdom—to make, and act well upon, right choices in a specific context of socio-ecological practice [for the concept of *ecophronesis*, see Austin (2018), Xiang (2016)] (Chen & Xiang 2020a, p.334).

With these provisions, since it took effect on the signing day, the agreement has enabled people from both counties to share canal benefits, and as such ably become a cornerstone for a lasting peaceful canal culture between the two peoples, even in the face of water use disputes (Shen 2020, pp. 198–210). It is indeed an extraordinary achievement.

Yet, equally if not more extraordinary is the process through which this agreement came about.

## 2 The agreement-making process and Yang Gui's motivation

According to Chinese historians Hao Jiansheng (郝建生) and Shen Shufeng (申树风), the 1962 agreement was the brainchild of Yang Gui [杨贵, (1928–2018)], the then Party

Secretary and top leader of Linxian County who masterminded the Red Flag Canal project (Hao et al. 2011, p. 155; Shen 2020, p. 118).<sup>4</sup> Upon the completion of the Pingshun segment on October 1, 1960, he reached out to the Pingshun leadership team with the idea of codesigning and signing a bilateral agreement and soon won their support (Hao et al. 2011, p. 155; Shen 2020, p. 118). With the blessing from both county leaderships, a joint taskforce led by Wang Jingwei (王经纬, Pingshun County) and Shi Yujie (石玉杰, Linxian County) drafted the agreement and revised multiple times with input and feedbacks from villagers and local officials along the Pingshun segment (Shen 2020, pp.118–120). The final version, shown in Fig. 1, was signed and took effect on August 15, 1962 (*Ibid.*, pp.120–122; Wang and Sang 1995, pp.148–150).<sup>5</sup>

This process of agreement-making was clearly self-initiated, participatory, and codesigning. At the end, it produced extraordinary results—a fair, workable agreement of which canal users from both counties willingly claimed their coownership. No wonder the agreement readily had the buy-in from all the parties involved (Shen 2020, p. 120, p. 122).<sup>6</sup>

But then, what is it that inspired Yang Gui to initiate the agreement-making process in the first place?

In their 2011 book *Yang Gui and the Red Flag Canal* (Hao et al. 2011), Hao Jiansheng and coauthors reveal the secret. Yang Gui did it for a simple reason, which he stated poetically years after presenting the agreement idea to the Pingshun leadership team:

“We are building the Red Flag Canal for posterity; we must do everything we can to save posterity the trouble.” (*Ibid.*, p.155)<sup>7</sup>

However, just *what* “the trouble” he perceived was, *who* the troublemaker he thought would be, and *why* he was

confident that a bilateral agreement on the four provisions could serve the noble goal “to save posterity the trouble”, Yang Gui did not reportedly say at the time of making above statement, neither did he leave any record in the Red Flag Canal project archives.<sup>8</sup> This situation created regrettably a gap in what people know about this important episode in the Red Flag Canal history—a knowledge gap, that is.

### 3 The knowledge gap, our opportunity, aspiration, and endeavor to close it

Admittedly, this gap came as no surprise. As a celebrated down-to-earth servant-leader,<sup>9</sup> Yang Gui was known for, *inter alia*, his intuitive talent for spotting problems even when they were still in the making and his laser-focused, relentless pursuit of pragmatic, workable solutions to the problems (Fig. 3). Much less if ever was he interested in finding out and/or documenting the scientific, general principles undergirding the problems and/or solutions. In this specific 1962 instance, he might well be overwhelmed by the urgently important need he perceived for a fair and actionable agreement between the two counties to attend to what he later called “the trouble” (Li et al. 2004, p. 109, p. 178; Shen 2020, pp. 118–119). As such, he would understandably have no time nor energy to dig into the literature of

<sup>4</sup> [1] Hao Jiansheng provided an example of how Yang Gui masterminded the project (Hao et al. 2011, pp. 119–121). Its English translation can be found in Xiang (2020a, pp.108–109). [2] The Party Secretary (党委书记 in Chinese) is an abbreviation of the First Secretary of the (Communist) Party Committee. For a succinct introduction of the role the Communist Party plays in the Chinese political system, see footnote 1 in Chen & Xiang (2020a, p.329).

<sup>5</sup> [1] We planned to post photos of Wang Jingwei and Shi Yujie as a token of our respect and admiration. Unfortunately, we could only find Wang Jingwei’s photo at the time of writing this article. [2] The statement “the completion of the Pingshun segment on October 1, 1960” is based on Wang & Sang (1995, p.57, p.441). In the 1962 agreement, however, the completion date is stated for unknown reason as “in November 1960” (the first paragraph, see Fig. 1).

<sup>6</sup> According to Shen Shufeng, author of the 2020 book *Stories of the Red Flag Canal’s headwaters*, for unknown reasons, one Pingshun village, Yanggao Village (阳高村), was neither involved in the agreement-making process, nor invited to the agreement signing on August 15, 1962 (Shen 2020, pp.149–150). This issue was resolved more than two decades later with the signing of an agreement between the village and the canal’s administration on October 16, 1986. The agreement has provisions comparable to those in the 1962 agreement (*Ibid.*, pp.148–151).

<sup>7</sup> [1] The Chinese text in Hao et al. (2011, p.155) is “杨贵说：‘修建红旗渠是为子孙后代谋幸福，决不能给子孙后代留麻烦。’红旗渠第一期工程修成后，他就派人到山西平顺县商讨一次买断红旗渠占地和占用渠首坝及坝内河滩的使用权。” [2] When exactly did Yang Gui make this statement? The authors of the 2011 book did not specify. Nonetheless, Hao Jiansheng confirmed in a WeChat interview that it was after, perhaps years after, Yang Gui presented the agreement idea to the Pingshun leadership team. The interview was conducted by the lead author of this article on April 29, 2021.

<sup>8</sup> [1] We reached this conclusion after a thorough search through the available literature and archives, including Yang Gui’s own memoir (Yang 1995). In his memoir, he does acknowledge the unselfish and unwavering support from the Pingshun people and their leadership team (*Ibid.*, p.476). [2] In the said WeChat interview on April 29, 2021, Hao Jiansheng was positive that Yang Gui used “the trouble” to refer to issues pertaining to the use of Pingshun land for the canal purpose.

<sup>9</sup> [1] A servant-leader, according to American leadership scholar-practitioner Robert Greenleaf (1904–1990) who coined the term, is “someone who believes that serving-others and self-healing are two sides of the same coin, and thus takes on the leadership role with a bona fide motivation ‘for his own healing’ (Greenleaf 1970/2008, pp. 37–38).” (Chen & Xiang 2020b, p.340) This concept holds a parallel meaning in China to that of *public servant leader* (人民的勤务员), a generic concept embedded in the constitutions of the Chinese Communist Party and the People’s Republic of China long before Robert Greenleaf’s work (*Ibid.*, pp.340–341; Han et al. 2010, p.265). [2] A 2019 compendium of articles in memory of Yang Gui, edited by Chinese author Hao Shuncai (郝顺才) provides many examples of Yang Gui as a caring and hands-on servant-leader (Hao 2019).





**Fig. 3** The down-to-earth servant-leader Yang Gui (the sitter at the center) talking with woman visitors (sitters to his right) at a Red Flag Canal project site in March 1960, one month after the official kickoff of the project on February 11, 1960. He was accompanied by Li Gui [李贵, (1913—1976)], the manager of Linxian County (to his left). They were surrounded by project participants from Linxian County. The photo was taken by Chinese photographer Wei Dezhong (魏德忠) and used here with his permission

scientific principles for inspirations, much less document “the trouble” and the troublemaker he spotted intuitively and the justifications for a bilateral agreement he envisioned.<sup>10</sup> Frankly, even if he were seeking guidance or inspirations

<sup>10</sup> In this capacity, he inadvertently employed “the Li approach to use inspired practice research for practice”. Commonplace among practitioners throughout human history, this approach was codified in 2021 by Chinese American geographer and planning scholar Wei-Ning Xiang (Xiang 2021, p.80, p.82). The approach is named after Li Bing (李冰), a Chinese engineer who masterminded the Dujiangyan irrigation system in Sichuan, China in 256 BC. Under this approach, a practitioner acts as a non-scientist researcher, exemplified by Li Bing, who “aims exclusively to find the right way to do the right thing for a particular instance of socio-ecological practice and [most often] leaves no record of his [or her] research on the undergirding principles.” (Xiang 2021, p.80) It should also be noted that Yang Gui was not alone. In fact, this approach was adopted and used widely by the project leadership team and the project participating farmers in every step of the project lifecycle, from planning, design to construction and management. An admirable remark by Qian Zhengying (钱正英), a Chinese hydrologist and the former Minister of Water Resources in China, says it all: “This [the Red Flag Canal] is the creation of the farmers, not the design of engineers.” (“这[红旗渠]是农民的首创而不是工程师的设计。”) (Hao et al. 2011, p.3).

from codified scientific principles, he could not find any in the scholarly literature at that time. This is because (1) it was not until the mid-1980s that scholars began to systematically investigate and reveal some of the pertinent principles through empirical research, and (2) their research findings were all published in English (a synthesis of their findings is provided in Sect. 4 of this article), and not available in Chinese until 2000. For instance, the 1990 book *governing the commons: the evolution of institutions for collective action* by American political economist Elinor Ostrom (1933–2012) documents her pathbreaking empirical research and insightful findings on the governance of common-pool resources, including irrigation canals (Ostrom 1990). The Chinese version was published ten years later in 2000 [for the Chinese title, see the References section of this article under “Ostrom E (1990)”].

Fortunately, half of a century later, researchers today are more ready than ever to close this knowledge gap systematically. This is so for three reasons. First, more and detailed information has been unearthed about the agreement-making process, thanks to historians Hao Jianshen and Shen Shufeng, among others. This is summarized at the beginning of Sect. 2. Second, after these many years, the 1962 agreement remains a credible piece of evidence, as recognized by the Red Flag Canal researchers (e.g., Hao et al. 2011; Li et al. 2004; Shen 2020; Wang and Sang 1995). And most importantly, since the four provisions in the agreement (see Sect. 1 of this article) are measures specifically improvised to mitigate “the trouble” (Hao et al. 2011, p. 155; Li et al. 2004, p. 121, p. 178), they may well provide useful hints from which researchers can infer what “the trouble” and who the troublemaker Yang Gui perceived were. Third, in the scholarly literature, there is now a rich collection of theoretical constructs on the defining characteristics of irrigation canal systems, common challenges they present to canal users, and various coping strategies canal users developed. These constructs are developed empirically by international researchers from diverse disciplinary backgrounds, ranging from anthropology, economics, and political science, to ecology, history, and irrigation engineering and management (e.g., Agrawal 2002; Bardhan and Dayton-Johnson 2002; Dietz et al. 2002; Ebright 2006; Lan and Peng 2020; Li et al. 2004; Loeffler and Loeffler 2012a, 2012b; National Academies of Sciences, Engineering, and Medicine 1996; Ostrom 1990, 2005, 2008a; Ostrom et al. 1994a, 1994b, 1999; Ostrom and Ostrom 1977, 2002; Phelps and Wre 2007; Regmi 2008; Rivera and Martínez 2009; Sarker and Itoh 2001, 2003; Siy 1982; Swentzell 2012; Tang 1994; Thanh et al. 2021; Wade 1987, 1988; Yan et al. 2017). These empirically derived constructs afford useful theoretical lenses through which researchers may examine this concrete instance along with available evidence in a

fresh systematic light to make discoveries and gain insights leading to the closure of the knowledge gap.<sup>11</sup>

Following this line of reasoning, we examined the 1962 instance via one such theoretical lens—a common-pool resource lens. Our lens choice was made deliberately. After a thorough literature search and comparative analysis of various lens options as summarized in the last paragraph under the third point, we became convinced that a lens built on economic constructs of common-pool resources best serves our needs. This is because it could ably allow us to examine, in a fresh systematic light, the 1962 agreement along with the best available evidence for discoveries and insights; the discoveries and insights such derived would in turn enable us to explore, in a meaningful and plausible way, answers to the following three questions:

- (1) What was “the trouble” Yang Gui perceived that impelled him to improvise the 1962 agreement and initiate the agreement-making process?
- (2) Who was the troublemaker Yang Gui had in mind that, if untamed, would cause “posterity”—the immediate and future Red Flag Canal communities—“the trouble”?
- (3) Why was Yang Gui confident that a bilateral agreement on the four provisions could serve the noble goal “to save posterity the trouble”?

As these questions represent the entire set of unknown components of the knowledge gap described above, their answers would put closure on the gap.

The results of our endeavor will be presented in Sect. 5. But first, what does the common-pool resource lens we built and used look like?

<sup>11</sup> It is worthwhile to point out that like in ordinary human cognition, to restore historical missing links through credible evidence and available knowledge is commonplace in scientific research. One relevant example is the revelation of the scientific and managerial principles underlying the successful construction and operation of 2300-year-old Dujiangyan irrigation system in Sichuan, China (Xiang 2021, pp.80–82). The practitioners, working as “non-scientist researchers”, had figured out these principles empirically and used them effectively in their socio-ecological practice of irrigation system construction, operation, and management far before the principles were formally codified by modern-day scientists (*Ibid.*, pp.81–82). The practitioners left no record of their research. It is only two millennia later when these undergirding principles were extrapolated by scientist researchers from the design characteristics of the irrigation system (Xiang 2019a, p.363; 2021, p.80).

## 4 A common-pool resource lens

A common-pool resource (CPR) lens (henceforth, CPR lens) is an eclectic collection of theoretical constructs about common-pool resources (CPRs), including irrigation canal systems, through which one can examine people’s behaviors and evaluate their motivations in an instance or instances of CPR governance practice for new discoveries and insights. The CPR lens we built comprises economic constructs from CPR theory and public goods theory about (1) the troublemaking nature of CPRs and its root cause, and (2) institutional arrangements as a practical instrument for taming the CPR troublemaker. These two lens components will be presented in Sects. 4.2 and 4.3, respectively. To set the stage, we begin with an economic nomenclature of goods.

### 4.1 Four types of goods in economics

The term *goods* in economics refers to natural resources and/or man-made products from which people may derive benefits to meet their various needs. Economists, following the trailblazing work of American economist Paul Samuelson (1915–2009) in the mid-1950s (i.e., Samuelson 1954, 1955), have developed a rigorous approach to classifying goods (Holcombe 2000, pp. 273–274; Sandler 2015, p. 197).

#### 4.1.1 Two publicness characteristics used in goods classification

Under this approach, economists use two clear-cut rules to distinguish among four types of goods, including CPRs (Araral 2014, pp. 11–12; Holcombe 1997, p. 2; 2000, pp. 274–275; Sandler 2015, pp. 196–198):

- (1) Goods are defined as *public*, pure or impure, if they possess one or both of publicness characteristics of *non-subtractability of benefits* and *non-excludability of benefits*;
- (2) Goods are defined as *private* if they do not meet any conditions in (1).

In (1), the term “publicness characteristic” (Holcombe 2000, p. 275), or “publicness property” as in Sandler (2015, p. 198), refers to a good’s inherent capability for public use.

*Non-subtractability of benefits* means that a good is so abundant in quantity and/or stable in quality that it allows people to derive benefits from it without subtracting the use and benefits of other users, existing and/or future (Dietz et al. 2002, pp. 18–19; Holcombe 1997, p. 2; 2000, p. 274; Li et al. 2004, pp. 21–22; Ostrom 2005, p. 23; Ostrom and

**Fig. 4** Four types of goods in economics [After “Fig. 1. Types of Goods” in Ostrom & Ostrom (1977, p.12); with updates based on Araral (2014, p. 19), Buchanan (1965, pp. 1–2), Dietz et al. (2002, pp. 3–5), Holcombe (2000, p. 274), Li et al. (2004, pp. 29–30), McCay (1995, pp. 92–93), Ostrom (2005, pp. 23–24; 2008a, pp. 10–11), Ostrom et al. (1994a, pp. 6–8), Sandler (2015, p. 198), Sandler and Tschirhart 1997, pp. 335–338; Scotchmer (2018)]

Publicness characteristics		Non-subtractability of benefits	
		Yes	No
Non-excludability of benefits	Yes	Public goods e.g., sunshine, weather forecasts, radio broadcast, etc.	Common-pool resources (CPRs) e.g., fishes in an ocean, irrigation canals, public open areas, etc.
	No	Club goods (Toll goods) e.g., neighborhood swimming pools, toll roads, etc.	Private goods e.g., personal belongings, one’s real estate, etc.

Ostrom 1977, pp. 10–12; Pacheco 2014, p. 107). A good with this capability (i.e., a non-subtractable good) enables a social state of *jointness* or *nonrivalry in (its) consumption* among the public (*Ibid.*) Some economists even use *jointness* or *nonrivalry in consumption* as a publicness characteristic in lieu of *non-subtractability of benefits* in goods classification (e.g., Ostrom and Ostrom 1977, pp. 10–12).

*Non-excludability of benefits* means that a good is so ubiquitously available and/or readily accessible that it allows just everyone at will and for free to derive benefits from it either without the usual cost and effort, or at other’s expense (Holcombe 1997, p. 2, p. 6; 2000, p. 274; Li et al. 2004, pp. 27–29; Ostrom 1990, p. 30; Ostrom 2005, p. 24; Pacheco 2014, p. 107; Sandler 2015, p. 198). A good with this “open access” capability (McCay 1995, p. 93), a non-excludable good, that is, makes it prohibitively costly or impractical to keep people from deriving benefits from the good itself, thereby engendering free rider incentives among the public (*Ibid.*).<sup>12</sup>

#### 4.1.2 A typology of goods

To construct a typology of goods abiding by the classification rules (1) and (2), economists begin with two intersecting straight-line axes, each presenting a dichotomy of said

publicness characteristic; on the fourfold table such derived, they subsequently define the four types of goods (Fig. 4).<sup>13</sup>

As shown in Fig. 4, the typology clearly delineates the boundaries among four types of goods. *Public goods* possess both publicness characteristics, whereas *private goods* possess none; in between these extreme classes are *club goods (toll goods)* and *common-pool resources (CPRs)*, each possessing one of the two publicness characteristics.<sup>14</sup> These two hybrid types are also referred to as “impure public goods” (Sandler 2015, p. 198) to distinguish them from the “pure public goods” (*Ibid.*, p. 196)—the *public goods* proper in the upper left cell of the fourfold table.

Our readers, especially those who are non-economists, would be better served by an in-depth review of all four types of goods in the typology. Since such a review is

<sup>12</sup> Herd immunity during a pandemic, such as the COVID-19 pandemic, is a good example of non-excludable good. With a large enough number of people getting vaccinated, herd immunity emerges. It effectively slows and eventually stops the spread of infections. When or even before this happens, individuals who choose not to get vaccinated can still benefit from herd immunity as free riders (Yong & Choy 2021, pp.1–2).

<sup>13</sup> Their choice of a dichotomy over a more precise continuum in presenting publicness characteristics is a deliberate one. This is evidenced by their acknowledgement of this imprecision in the economic literature [e.g., Buchanan (1965, pp.1–2), Dietz et al. (2002, pp.3–4), Holcombe (2000, p.276), among others]. Furthermore, the choice is an effective one—the imprecision turns out to be precise enough for the purpose of goods classification, and the typology built on the dichotomies a useful heuristic aid for non-economist researchers like us as well as economists.

<sup>14</sup> In their 2004 book *China’s Red Flag Canal: its resource background and institutional arrangements*, Chinese economist Li Luliang (李露亮) and his colleagues use the following Chinese translations: 公共资源 for public goods, 私有资源 private goods, 垄断资源 club goods (toll goods), and 共有资源 common-pool resources (Li et al. 2004, pp.29–30). Their careful word choices of 共有资源和 公共资源 help readers to appreciate the difference between common-pool resources and public goods. In a WeChat exchange on June 21, 2021, with the lead author of this article, Li Luliang used 物品 in lieu of 资源 in these translations and suggested that club goods be translated to 垄断/俱乐部物品.

beyond the scope of this article, we recommend instead the readings in-text-cited above as a complement. Of particular interest among them is a 1977 synthesis of the four types of goods by American political economists Vincent Ostrom (1919–2012) and Elinor Ostrom. The Ostroms purported to use the synthesis (Ostrom and Ostrom 1977, pp. 9–18) as a base to introduce public goods theory, a cornerstone economic theory of public sector since the 1950s (Holcombe 2000, p. 273), to the fields of political science and public administration (Lowery 2013, p. 166). “While [even then] much of this pedagogical work was not new” (*Ibid.*), we still found the synthesis inspirational and useful 44 years later in 2021, and as such recommend highly to our readers.<sup>15</sup>

## 4.2 The troublemaking nature of CPRs and its root cause

As shown in Fig. 4, CPRs are a type of impure public goods, or “a sub-set of public goods” (Ward 1987, p.96), that is non-excludable and subtractable (Li et al. 2004, p. 29; Ostrom et al. 1994a, p. 4; Ostrom et al. 1999, pp. 278–279; Ostrom and Ostrom 1977, p. 12; Ward 1987, p. 96). A core feature of CPRs is their benefitting—troublemaking duality, a perpetual, odd, and maddening phenomenon.

<sup>15</sup> [1] Specifically, we recommend the Ostrom synthesis for two reasons. First, the synthesis is authentic and systematic, its presentation perspicuous. The Ostroms made a painstaking effort along two frontiers. They stucked closely to the classic fundamentals of public goods theory founded on Paul Samuelson’s seminal work (1954, 1955); and presented the highly technical materials with what Wei-Ning Xiang calls “the strategy of writing in small words for big circles” (Xiang 2020b, p.124). Their dual effort shows throughout the synthesis and manifests best in “Fig. 1. Types of goods” and “Table 1. Public and Private Goods” (Ostrom and Ostrom 1977, p.12 and p.16, respectively). The authentic typology and perspicuous presentation together allow non-economist readers like us to readily appreciate the defining characteristics of different goods in a systematic, comparative fashion. The chapter amassed 1234 Google Scholar cites as of May 7, 2021; and was included later in a 2002 edited book *Polycentricity and local public economies* (Ostrom & Ostrom 2002). Second, the synthesis is highly relevant to our lens-building endeavor. With a clear delineation of CPRs, not only did the synthesis remove the cloud of ambiguity about the relationship of CPRs to (pure) public goods (McCay 1995, p.92; Ostrom 1990, p.32, p.221), it also set the rigorous stage for the scholarly CPR research that kicked off several years later in the 1980s (Basurto 2015). Among many fruitful pursuits of this lasting intellectual movement that are directly relevant to our lens-building are three pieces of research. One is the influential CPR research on irrigation canals by Elinor Ostrom as documented in the said 1990 book (Ostrom 1990); and the second is the fine-grain CPR investigation on institutional arrangements in the Red Flag Canal by Li Luliang and his colleagues as reported in their 2004 book (Li et al. 2004); the third is specifically on CPR challenges in irrigation systems by British economist Robert Ward (Ward 1988). [2] Throughout the article, parentheses in direct quotations are by the authors of this article unless noted otherwise.

### 4.2.1 CPR’s benefitting—troublemaking duality

On the one hand, CPRs are benefitting—they are a valuable source of benefits that provides many services to the human beings. Examples of CPRs and their services include, but are not limited to, open oceanic ecosystems from which fishes are harvested and into which effluents are discharged<sup>16</sup>; the earth’s atmosphere into which greenhouse gases are released; forest ecosystems from which timber is harvested; irrigation canal systems from which water is withdrawn (Dietz et al. 2002, p. 3; Li et al. 2004, p. 29; Ostrom 2008a, p. 11; Tang 1994, p. 225; Ward 1987, p. 96); and urban public parks and greenways on which people participate in various social-recreational activities and enjoy many health and moral benefits [Crompton 2013, pp. 217–218; 2017, p. 106; for a showcase of the Beijing Olympic Forest Park as an exemplary benefitting CPR, see Wu et al (2021)].

On the other hand, however, CPRs are troublemaking—they are often a fundamental reason of disputes or even conflicts that causes troubles for the human beings. Throughout the human history, conflicts over CPR use (henceforth, CPR conflicts) are a notorious, remorseless socio-ecological reality (Ostrom et al. 1994a, pp. 3–5; Ostrom et al. 1999, p. 278). Take water-related CPR conflicts for example. *The water conflict chronology*—a comprehensive, yet by no means complete, open-source database by the Pacific Institute in Oakland, California, USA—archives over 900 worldwide incidences of water-related CPR conflicts and violence, some of which reportedly occurred as far back as 3000 BC (The Pacific Institute 2019). These cases fall into three telling categories, depending on whether water and/or water systems involved were (1) triggers of conflicts, (2) used as weapons in conflicts, or (3) targets or casualties of violence (*Ibid.*). This daunting socio-ecological reality of water-related CPR conflicts and the concomitant futility of escape have been experienced by millions of people around the world throughout the ages and are best depicted by the American adage “Whiskey is for drinking, water is for fighting” (Ebright 2006; Phelps and Wre 2007; Quote Investigator 2013).<sup>17</sup>

The question is, what is the root cause of this duality? Or more precisely, what is the root cause of CPRs’ troublemaking nature—what is it that makes benefitting CPRs “a troublemaker”?

<sup>16</sup> Among many examples for the latter category of human actions is the recently announced plan by the Japanese government to release Fukushima’s wastewater into the Pacific Ocean (Normile 2021).

<sup>17</sup> The claim by many that the adage is attributed to American writer Mark Twain (1835–1910) is moot, see, for example, Quote Investigator (2013).



**Table 1** Eight key IA elements frequently observed in the effective institutional arrangements (the Ostrom key IA elements), their purposes and mitigation targets

	Purposes	Mitigation targets
	The Ostrom Key IA elements (see note [1] below)	
1	<b>Clearly defined boundaries.</b> The boundaries of the resource system, such as irrigation systems or fisheries, and the individuals or households with rights to harvest resource units are clearly defined (see note [2] below)	Non-excludability and the concomitant free rider incentive and behavior (overuse & gross negligence, see 4.2.2); Subtractability and user rivalry
2	<b>Proportional equivalence between benefits and costs.</b> Rules specifying the amount of resource products that a user is allocated are related to local conditions and rules requiring labor, materials, and/or money inputs	Same as the above
3	<b>Collective-choice arrangements.</b> Many of the individuals affected by harvesting and protection rules are included in the group who can modify these rules	The unbounded interplay of non-excludability and subtractability with a focus on user rivalry
4	<b>Monitoring.</b> Monitors, who actively audit biophysical conditions and user behavior, are at least partially accountable to users and/or are users themselves	The inbounded interplay of non-excludability and subtractability
5	<b>Graduated sanctions.</b> Users who violate rules-in-use are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, officials accountable to these users, or both	Non-excludability and the concomitant free rider incentive and behavior (overuse & gross negligence)
6	<b>Conflict-resolution mechanisms.</b> Users and their officials have rapid access to low-cost, local arenas to resolve conflict among users or between users and officials	The interplay of non-excludability and subtractability with a focus on user rivalry
7	<b>Minimal recognition of rights to organize.</b> The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource	Non-excludability
8	<b>Nested enterprises (for resources that are parts of larger systems).</b> Appropriation, provision, monitoring, enforcement, conflict-resolution, and governance activities are organized in multiple layers of nested enterprises (see note [4] below)	Non-excludability

Notes: [1] The text about the eight key elements is from the box “Design principles for governing sustainable resources” in Ostrom (2008a, 2008b, p. 18); an earlier version of the box is in “Table 3.1. Design principles illustrated by long-enduring CPR institutions” (Ostrom 1990, p. 90); a detailed element-by-element discussion, drawing on empirical research of effective, self-governing, small- to medium-sized CPR systems from around the world (Ostrom 1990, p. 182; 2008, p. 18), can be found in Ostrom (1990, pp. 91–102). For this reason, we call these elements “the Ostrom key IA elements.” [2] “Resource units are what individuals appropriate or use from resource systems. Resource units are typified by the tons of fish harvested from a fishing ground, the acre feet or cubic meters of water withdrawn from a groundwater basin or an irrigation canal ...” (Ostrom 1990, p. 30). [3] “A club is a voluntary group deriving mutual benefits from sharing one or more of the following: production costs, the members’ characteristics, or good characterized by excludable benefits.” (Sandler and Tschirhart 1997, p. 335). In his 1965 seminal article, American economist James M. Buchanan (1919–2013) explains the rationale for this CPR-to-club-good transformation. To mitigate the otherwise unbounded interplay between non-excludability and subtractability and avoid the mutually destructive plowshares-to-swords process (see 4.2.2), it is more efficient to make “the range of ‘publicness’ [of a CPR] ... finite” such that the group sharing the particular good, the club, that is, “is more than one person or family but smaller than an infinitely large number.” (Buchanan 1965, p. 2) To form and sustain a club of this kind, “the quantity of the good, the size of the club sharing in its consumption, and the cost-sharing arrangements must be determined simultaneously.” (*Ibid.*, p. 12) Following Buchanan’s seminal work, club theory has subsequently developed to focus both on interactions among the club members and the goods they share (Scotchmer 2018). Most, if not all, of the eight key IA elements listed here are somewhat related to these two aspects of club theory. However, Elinor Ostrom did not cite Buchanan (1965) when presenting the very eight key IA elements in her classic study report (i.e., Ostrom 1990), nor did she mention club theory. [4] *Appropriation* refers to the process of withdrawing resources from a CPR system (Ostrom 1990, p. 30). [5] In illustrating “nested enterprises” in her 1990 book, Elinor Ostrom uses two CPR governance systems, one with a marble-cake structure and the other a layer-cake structure (1990 pp. 101–102). “In the Spanish *huertas* [sic, the English translation is *produce farms*], for example, irrigators are organized on the basis of three or four nested levels, all of which are then also nested in local, regional, and national governmental jurisdictions. There are two distinct levels in the Philippine federation of irrigation systems.” In both “nested enterprises”, irrigators devised “appropriation and provision rules” that were “well-tailored” to the structures of respective CPR governance systems (*Ibid.*, p. 92). Later, she and her colleagues stress, drawing on examples of unsuccessful institutional arrangements, that to be effective and resilient, “(i)stitutional arrangements must be complex, redundant, and *nested* in many layers [of CPR governance systems].” (Dietz et al. 2003, p. 1910; italic by the authors of this article)

#### 4.2.2 The root cause: the unbounded interplay of non-excludability and subtractability

It was not until the mid-twentieth century that CPRs' troublemaking nature and its root cause began to be revealed systematically in the scholarly literature published in English. This intellectual movement was sparked primarily by the 1968 seminal essay *The tragedy of the commons* by American ecologist Garrett Hardin (1915–2003).<sup>18</sup> Below we provide a synthesis of this literature through a classic prototypical scenario whose first edition appeared in Hardin's 1968 essay (p. 1244).

The prototypical scenario describes a plowshares-to-swords process in which the interplay of non-excludability and subtractability, as Hardin puts it, following strictly “the inherent [CPR] logic”, “remorselessly generates tragedy [of CPR deterioration and social-political conflicts].” (Hardin 1968, p. 1244) Here, non-excludability and subtractability are CPRs' two defining features. As shown in Fig. 4, *non-excludability* itself is a publicness characteristic, whereas *subtractability* is the very antithesis of the other publicness characteristic *non-subtractability* (for definitions of these two publicness characteristics, see 4.1.1). As a subtractable good, a CPR by nature entails competition and rivalry among users because its consumption by one individual will necessarily subtract the use and benefits of other users, existing and/or future. Therefore, the interplay of non-excludability and subtractability described below in the prototypical scenario is in essence one between the free rider incentive and user rivalry engendered, respectively, by these two CPR features.

At the beginning of this plowshares-to-swords process, not only does CPRs' innate resistance to user exclusion (*non-excludability*, that is) incite the free rider incentive among all users (see the last paragraph in 4.1.1), it also enables and even urges individuals or groups to derive benefits from CPRs in willful pursuit of short-term, selfish interests at the expense of long-term, collective interests (Dietz et al. 2002, p. 3; Hardin 1968, p. 1244; Hardin 1998; Li et al. 2004, pp. 31–35; Ostrom et al. 1999, pp. 278–279; Rose 1986, p. 712; Ward 1988, p. 490). Such a selfish pursuit can take one or both of the free-riding forms: CPR overuse with little concern for the negative effects on others; gross negligence to CPR maintenance and management (Dietz et al. 2002, p. 3; Li et al. 2004, pp. 31–35; Ostrom et al. 1994a,

pp. 3–5; Ostrom et al. 1999, pp. 278–279).<sup>19</sup> Once the initial free riders begin to enjoy their short-term bonus, the other CPR property *subtractability* kicks in inexorably and manifests itself with perceptibly reduced or even diminishing CPR supplies.<sup>20</sup> This often conspicuous situation in turn helps lure more individuals or groups into intense competitions, turning the process into a rat race which is cherished by CPRs' *non-excludability*.<sup>21</sup> Competitions of this nature, escalating as time goes by, lead to CPR deterioration or even depletion and invoke fierce social-political conflicts—CPR conflicts (Dietz et al. 2002, p. 3; Hardin 1968, p. 1244; Hardin 1998; Li et al. 2004, pp. 31–35; Ostrom et al. 1999, pp. 278–279; Ward 1988, p. 490). The process culminates with a mutually destructive tragedy—a CPR tragedy, in which everyone is a loser (Hardin 1968, p. 1244; Ostrom et al. 1999, p. 278; Rose 1986, p. 712).

This scenario, with its pessimistic plot and tragic ending, makes a plausible case for the root cause of CPRs' troublemaking nature. That is, when unbounded, the inherent interplay between CPRs' two defining features, non-excludability and subtractability, inevitably turns benefiting CPRs into “a troublemaker”; and “the trouble” they cause the human beings includes, *inter alia*, the deterioration in the quality and quantity of CPR supplies, the loss of CPR services,

<sup>19</sup> We borrow the legal term *gross negligence* here as we believe that it accurately describes the willful, selfish behavior of CPR free-riding users which, as many suggest (e.g., Hardin 1968, p.1244; Hardin 1998; Ostrom et al. 1999, p.278; Ward 1988, p.490), can lead to the destruction of a CPR. Gross negligence, by definition, refers to “negligence that is marked by conduct that presents an unreasonably high degree of risk to others and by a failure to exercise even the slightest care in protecting them from it and that is sometimes associated with conscious and willful indifference to their rights.” (Merriam-Webster.com Dictionary 2021) In the above definition, negligence means “failure to exercise the degree of care expected of a person of ordinary prudence in like circumstances in protecting others from a foreseeable and unreasonable risk of harm in a particular situation.” (*Ibid.*) In this CPR context and for our later discussions on Yang Gui's motivation to initiate the 1962 agreement, we suggest that 蓄意的严重疏忽 be the Chinese translation of *gross negligence*.

<sup>20</sup> For renewable CPRs, diminishing supplies refer to a state where the rate of CPR renewal or refill is behind that of use (Ostrom et al. 1999, p.279).

<sup>21</sup> Earlier editions of the prototypical scenario assume that individuals do not know what and how others are doing (Ostrom 1990, p.183; 2008b, pp.25–26). But as American legal scholar Carol Rose points out, in many instances of CPR governance practice, any member of a user community can readily observe other users' behaviors and perceive their impacts on a CPR their lives depend on (Rose 2002, p.239). She provides an example of irrigation canal system. “Resource-related activities involved in irrigating—taking water from ditches, laboring on infrastructure development and upkeep—are especially open to mutual monitoring. Not only can one farmer observe another farmer along the same ditch, but upstream and downstream communities can observe what other communities are doing with respect to water use and infrastructure maintenance.” (*Ibid.*).

<sup>18</sup> For a review of this intellectual history, see Dietz et al. (2002, pp.6–17); for Hardin's original contribution and a sequel, see Hardin (1968; 1998).

and the emergence and escalation of CPR conflicts. In this capacity, the scenario fares well in explaining a good number of real-world CPR tragedies, including some of those archived in *The water conflict chronology* aforementioned.

#### 4.2.3 The reality check: half the story vs the whole story

The prototypical scenario has been under theoretical and empirical scrutiny ever since its first edition appeared in Hardin's essay in 1968 (Dietz et al. 2002, pp. 11–16; Dietz et al. 2003, p. 1907; Ostrom 2008b, p. 25). With the rich literature amassed from this line of multidisciplinary scholarship in the past 53 years, two things now become crystal clear:

- (1) The prototypical scenario uses three extreme, worst-case premises. The first is that humans are “always individual maximizers”—individuals are motivated exclusively by narrow self-interest, giving little concern for the welfare of other humans and/or other species on the earth [Dietz et al. 2002, pp. 3–5, p. 28; Li et al. 2004, p. 36; Rose 2002, p. 234 (the quote)]; the second is that ordinary people have little “psychological, social, and moral wherewithal to arrive at cooperative arrangements on matters of common interest.” (Rose 2002, p. 234); and the third is that anything goes—there are not readily enforceable and economically efficient rules of any kind for the individuals to follow that limit their access to and/or regulate their use of CPRs (Dietz et al. 2002, p. 5; Ostrom 1990, p. 61; Ostrom et al. 1999, p. 279). With these assumptions, under this worst-case scenario, people themselves are neither willing nor able to develop and follow rules that regulate their behavior in CPR use (Ostrom 1990, p. 46, p. 182).
- (2) As such, this worst-case scenario, as heuristically useful as it is,<sup>22</sup> at best tells only half the story from one vantage point (Dietz et al. 2002, pp. 3–4, p. 16; Dietz et al. 2003, p. 1907; McCay 1995, pp. 89–90; Ostrom et al. 1999, p. 278; Rose 1986, p. 723; 2002, p. 234). For the most part, “things [in the real world and throughout human history] are not as simple [and bad] as they seem in the prototypical model [i.e., the prototypical scenario]” [Dietz et al. 2002, p. 3 (the quote); McCay 1995, p. 110; 2002, p. 393; Rose 1986, p. 723]; and the whole story of CPR governance that we know so far

is about a perpetual drama of multiple episodes that entails a mix of tragedy, comedy, and even romance (Dietz et al. 2002, pp. 3–4; McCay 2002, p. 391, p. 393; Rose 1986).

Among those who first used the *comedy* and *romance* metaphors in this context are American scholars Carol Rose and Bonnie McCay. In a 1986 essay *The comedy of the commons: custom, commerce, and inherently public property*, Carol Rose points out (p. 723) that some CPR governance practices are “not tragic, but comedic, in the classical sense of a story with a happy outcome.” In a 1995 essay *Common and private concerns*, anthropologist Bonnie McCay advocates (p. 110) that, in lieu of the comedy, “(i)t might be better to try the metaphor of the romance of the commons [i.e., the CPRs].” This is because “(r)omance implies a far more complex development of character, situation, and plot [than comedy does] and hinges upon the tension of not knowing what the outcome will be, but hoping for the best. As a literary metaphor, it comes closer to the anthropological endeavor [to tame the CPR troublemaker].” (*Ibid.*)

Indeed. Throughout the ebb and flow of human history, there has been, and still is, a persistent “anthropological endeavor” to bound and mitigate the troublemaking interplay of non-excludability and subtractability in CPR use (Dietz et al. 2003, pp. 1907–1908). One of the instruments people developed for and used in this endeavor is that of institutional arrangements (*Ibid.*; Ostrom 1990, pp. 88–102), which will be discussed next.

#### 4.3 Institutional arrangements as a practical instrument for taming the CPR troublemaker

In the CPR literature, institutional arrangement is a construct derived from the real-world practice of CPR governance, thanks to the multidisciplinary empirical research work led by Elinor Ostrom since the mid-1980s [e.g., Blomquist 1987; Dietz et al. 2002; Ostrom 1985, 1987, 1988, 1990, 2008a, 2008b; Ostrom et al. 1994a-b; Ostrom et al. 1999; the Ostrom Workshop Library, 2021; For a review of this intellectual history, see Dietz et al. (2002, pp. 6–17)].<sup>23</sup> The term *institutional arrangement* (IA for short) refers to a coherent set of communal rules (henceforth, the IA rules) a group of people set and administer “to constrain individual [CPR users’] behavior that would, if unconstrained, reduce joint

<sup>22</sup> As a cognitive apparatus, a scenario is heuristically useful when it “stretches people’s thinking and broadens their views” (Xiang and Clarke 2003, p.885). The prototypical scenario, as Elinor Ostrom puts it (1990, p.183), is “useful for predicting behavior in large-scale CPRs in which no one communicates, everyone acts independently, no attention is paid to the effects of one’s actions, and the costs of trying to change the structure of the situation are high.”

<sup>23</sup> [1] A hallmark event for this line of scholarship is the 1985 Annapolis conference in Maryland, USA, which brought together scientists from different fields and different nations to examine common-pool resources and their governance (Dietz et al. 2002, pp. 7–14). [2] The Ostrom Workshop at the Indiana University in the US maintains a useful repository of CPR research findings, which includes a digital library of the commons [see the Ostrom Workshop Library (2021)].

returns to the community of [CPR] users.” [Ostrom 1990, p. 20 (the quote), pp. 40–41, pp. 51–55; Ostrom et al. 1994b, p. 219; Ostrom et al. 1999, p. 279]<sup>24</sup> Designed for the pragmatic purpose of taming the CPR troublemaker, these IA rules include key elements (henceforth, key IA elements) that aim to mitigate the troublemaking interplay of non-excludability and subtractability and manage the concomitant free rider incentive and user rivalry (see 4.2.2). Some of these key IA elements have “repeatedly been found” by the CPR researchers in the effective institutional arrangements underlying many small- to medium-sized sustainable CPR systems [Blomquist 1987, p. vii; Ostrom 2008a, p. 18 (the quote); Ostrom et al. 1994a, 1994b, p. 5] and were subsequently documented in the CPR literature published in English (e.g., Ostrom 1990, 2008a, 2008b; Ostrom et al. 1999; the Ostrom Workshop Library, 2021).

### 4.3.1 Key IA elements found in the effective institutional arrangements

In Table 1, we list eight key IA elements that are commonplace in the long-enduring sustainable institutional arrangements Elinor Ostrom archived in her classic CPR study (1990, p. 90, p. 103; 2008a, p. 18) and name them *the Ostrom key IA elements*. To put in perspective, we tabulate them with the *purposes* they were aimed at serving and the *mitigation targets* they were designed to tackle: the troublemaking interplay of non-excludability and subtractability, and the concomitant free rider incentive and user rivalry. To help maximize readers’ experience with this synthesis, we suggest to our readers that they (1) read, instead of just “look at”, the table element-by-element; (2) follow the logical sequence of “Key IA elements”—“Purposes”—“Mitigation targets” when reading the descriptions about each element; and (3) read the notes at the bottom of the table.

### 4.3.2 The people who made and administered the effective institutional arrangements

Who are the people in the documented instances of sustainable CPR governance practice that set and administered effective IA rules entailing some, if not all, of the Ostrom key IA elements? The answer is, self-organized users in CPR governance systems that are either self-governed or co-governed.

CPR governance systems are institutions through which people make and administer CPR policies, including

institutional arrangements (Ostrom 1990, p. 103). In the CPR literature, four basic types of CPR governance systems have been identified. These are systems featuring, respectively, (1) centralized governance by an external Leviathan—a government regulating body; (2) government-established decentralized governance by private property owners or enterprises; (3) grassroots self-governance by the community of self-organized CPR users who may or may not be property owners, and (4) co-governance through a partnership between local governments and self-organized CPR users (Dietz et al. 2003, pp. 1907–1908; Li et al. 2004, p. 275, pp. 281–286; Ostrom 1990, pp. 8–21; Ostrom 2008a, p. 11).

The self-organized users in self-governed or, in some instances, co-governed CPR governance systems [i.e., those of type (3) or (4) aforementioned] turn out to be effective IA makers and administrators in their very own right, outperforming the external government regulators and the private property owners under governments’ auspices in other two types of governance systems (Blomquist 1987, p. vii; Dietz et al. 2003, pp. 1907–1908; Rose 2002, pp. 234–235). As Thomas Dietz, Elinor Ostrom and Paul Stern point out, “(l)ocally evolved institutional arrangements governed by stable communities [of CPR users] and buffered from outside forces have sustained [common-pool] resources successfully for centuries” (Dietz et al. 2003, p. 1907). This conclusion is empirically valid and has been vindicated by hundreds of examples of long-lasting, sustainable CPR self-governance or co-governance practice throughout human history and around the world (*Ibid.*, p. 1908). These documented exemplary instances are from a wide range of communities in subsistent as well economically more advanced societies (*Ibid.*). They include, but are certainly not limited to, those identified between the 1980s and 1990s in “Turkish fisheries, Japanese and Swiss grazing communities, ancient and modern Spanish irrigation systems, communal forestry in India and Indonesia, wetlands management by medieval English ‘fen people,’ fishing and hunting practices among northern Canadian clan groups, lobster fishing communities in Maine [in the US]” (Rose 2002, p. 234). They should also include those more recently identified and reported—the 2300-year-old Dujiangyan irrigation system in Sichuan, China (Xiang 2014; Yan et al. 2017), the acequias in the arid Southwestern United States (Ebriht 2006; Rosenberg et al 2020),<sup>25</sup>

<sup>24</sup> [1] In their 2004 book, Li Luliang and his coauthor colleagues use 制度安排 as the Chinese translation of “institutional arrangement” (Li et al, 2004). [2] In the common-pool resource (CPR) literature, “institutional arrangement” and “governance arrangement” are often used interchangeably (e.g., Ostrom 2008a, p.10).

<sup>25</sup> Acequias refer to irrigation canals in the Southwestern United States (Collins Online Dictionary 2021). “Acequias are ancient ditch systems brought from the Iberian Peninsula to the New World over 400 years ago; they are simultaneously gravity flow water delivery systems and shared water governance institutions.” (Fernald et al. 2012, p.2998).



the major watersheds in the American Southwest (Loeffler 2012a), and the Red Flag Canal (Li et al. 2004).<sup>26</sup>

## 5 Discoveries and insights derived via the CPR lens and the knowledge gap closure they led to

The CPR lens described above served our needs well. It allowed us to examine, in a fresh systematic light, the 1962 agreement along with the best available evidence for new discoveries and insights; the discoveries and insights such derived in turn enabled us to explore, in a meaningful and plausible way, answers to the three questions raised in Sect. 3. As these questions represent the entire set of unknown components of the knowledge gap described also in Sect. 3, their answers put closure on the gap. Following this line of reasoning, we present our findings below.

### 5.1 “The trouble” and troublemaker Yang Gui perceived

With the help of the CPR lens, we found the targets the four provisions in the 1962 agreement aimed to mitigate, which led us toward answers to the first two questions raised in Sect. 3.

#### 5.1.1 The mitigation targets of the four provisions

In examining the 1962 agreement via the CPR lens, we first found a *parallel in functionality* between the four provisions in the agreement (See Sect. 1 for contents of these provisions) and the communal rules for CPR governance in the institutional arrangements Elinor Ostrom and other researchers documented (e.g., those mentioned in the last paragraph of 4.3.2). As presented in Sect. 1, the four provisions work coherently to (1) set the geographic boundaries of the Pingshun segment of the Red Flag Canal, (2) define the community of canal users from the two counties, (3) specify their rights and duties, (4) establish a shared canal stewardship, and (5) mandate a compensation. In this capacity, they function to serve the purpose of CPR governance, just as their

counterparts do in those documented institutional arrangements (see 4.3).

Following the lead of this similarity in functionality, we then discovered *an overlap in composition*—the four provisions in the 1962 agreement entail almost all the Ostrom key IA elements frequently observed in the effective institutional arrangements Elinor Ostrom documented. This striking finding is presented in Table 2.<sup>27</sup> It led us to the discovery of *the mitigation targets of the four provisions*. The Ostrom key IA elements are “active ingredients”, for lack of a better term outside the pharmaceutical industry, for taming the CPR troublemaker (see 4.3.1). As synthesized in Table 1, they target specifically the troublemaking interplay of non-excludability and subtractability and the concomitant free rider incentive and user rivalry; and become effective when properly integrated into communal rules or provisions in mitigating these targets (see the last column “Mitigation targets” in Table 1). Loaded with these active ingredients, the four provisions must take aim at, beyond any doubt, the same mitigation targets Elinor Ostrom documented in those effective institutional arrangements.

#### 5.1.2 “The trouble” and its maker Yang Gui had in mind

In Sect. 3, we raised the questions about (1) what “the trouble” Yang Gui perceived was that impelled him to improvise the 1962 agreement and initiate the agreement-making process and (2) who the troublemaker Yang Gui had in mind was that, if untamed, would cause “posterity”—the immediate and future Red Flag Canal communities—“the trouble”. The last discovery about the mitigation targets of the four provisions in the 1962 agreement enabled us to answer these questions for a straightforward reason. Since the four provisions are measures specifically improvised under Yang Gui’s auspice in 1962 to mitigate what he perceived as “the trouble” (Hao et al. 2011, p. 155; Li et al. 2004, p. 121, p. 178), then their mitigation targets should point directly to “the trouble” and the troublemaker he had in mind. To the

<sup>26</sup> In their 2004 book, Li Luliang and his coauthor colleagues designate the governance system in the Red Flag Canal before 1992 as type 4—co-governance (政府协助治理) (p.275, pp.283–286). In 1992, it gave way to type 1—a centralized governance system by a government regulating body for the upper stream portion of the Zhuozhang River watershed 漳河上游管理局 (Wang & Sang 1995, pp.279–280).

<sup>27</sup> One reason we consider this discovery striking is that the overlap in composition was found in an agreement for an irrigation system (a CPR) that is much larger than those Elinor Ostrom studied and documented. “I focus entirely on small-scale CPRs, where ... the number of individuals affected varies from 50 to 1 5,000 persons who are heavily dependent on the CPR for economic returns. These CPRs are primarily inshore fisheries, smaller grazing areas, groundwater basins, irrigation systems, and communal forests.” (Ostrom 1990, p.26) To paraphrase, the persons who are heavily dependent on the Red Flag Canal for economic returns are over half a million (Xiang 2020a, p.105).

**Table 2** The Ostrom key IA elements found in the 1962 agreement

The Ostrom Key IA elements		Provisions (rules) in the agreement			
		A permanent easement	The right to use canal water	A shared canal stewardship	A compensation payout
		I	II	III	IV
1	Clearly defined boundaries (and users)	✓	✓	✓	
2	Proportional equivalence between benefits and costs	✓	✓	✓	✓
3	Collective-choice arrangements			✓	
4	Monitoring			*	
5	Graduated sanctions			*	✓
6	Conflict-resolution mechanisms			*	✓
7	Minimal recognition of rights to organize	✓	✓	✓	
8	Nested enterprises (for resources that are parts of larger systems)	*	*	*	

[1] For definitions of the Ostrom key IA elements, the purposes they are aimed at serving and the mitigation targets they are designed to tackle, see Table 1; for the contents of the provisions, see Sect. 1; [2] The check mark ✓ indicates that we found an explicit relation between an Ostrom key IA element and a provision; while \* indicates that we inferred an implicit relation between the two

two questions, below are the answers this discovery led us toward.<sup>28</sup>

In Yang Gui's mind, the Pingshun segment of the Red Flag Canal was the potential troublemaker. He must have discerned the innate benefiting—troublemaking duality of this CPR, and foreseen that the interplay between this CPR's defining characteristics of non-excludability and subtractability, if unbounded, would inevitably cause “posterity”—the immediate and/or future canal communities—“the trouble”. He might have played the worst-case scenario Garrett Hardin later formally presented in *The tragedy of the commons* (see discussions in 4.2.2 and 4.2.3), and imagined a variety of forms “the trouble” could take. These might include one or any combination of the following: the overuse of canal water with little concern for the negative effects on

others, gross negligence to the segment's maintenance and management, the deterioration in the quality and quantity of canal water supplies, the emergence and escalation of water use conflicts between the two counties which might result in an ultimate takeover of the Pingshun segment by the Pingshun county and the loss of irrigation services in the canal's Linxian segment—a mutually destructive tragedy in which everyone is a loser. “To save posterity the trouble”, he must have felt impelled to tame the troublemaker through substantial and practical measures, and therefore initiated the agreement-making process.

## 5.2 Three sources of Yang Gui's confidence

Also in Sect. 3, we asked why Yang Gui was confident that a bilateral agreement on the four provisions could serve the noble goal “to save posterity the trouble”. The three discoveries presented in 5.1.1 about the four provisions of the agreement provided clues that led us toward a plausible explanation. He was confident because he would most likely have envisioned and been convinced that (1) the four provisions, by virtue of their functionality, composition, and mitigation targets we dug up only 60 years later (see 5.1.1), would be capable measures for mitigating “the trouble”; (2) they together make up a practical instrument—an institutional arrangement, that is, as was formally codified later in the CPR literature in the mid-1980s (e.g., Ostrom 1985, 1987, 1988)—for taming the troublemaker; and (3) such an instrument would be effective in mitigating “the trouble”, once adopted by both counties and instituted through a bilateral agreement.

<sup>28</sup> In both formulating the three questions in Sect. 3 and answering them here in this section, we managed to immerse ourselves in a situation we believed comparable to the one Yang Gui was in and imagined playing his role as the mastermind of the Red Flag Canal project. This approach is characterized figuratively as “being in dialogue with a historical figure” and has been advocated by many Chinese historians, such as Chen Yinke [陳寅恪 (1890—1969)] and Zhang Kaiyuan [章开沅, (1926—2021)] (Guangzhou Daily 2014). We found this approach effective throughout the entire life cycle of our research, from asking to answering questions. In our article writing, however, we had to use an ahistorical language, one that consists in words and theoretical constructs (i.e., the CPR lens) that were unavailable when the 1962 instance took place. Such a language allows us to communicate effectively with contemporary readers our aspiration and endeavor to fill this knowledge gap via the CPR lens. The imprecision associated with this transformative process is arguably inevitable.

Besides, there are two additional factors that might also have contributed to his confidence-building, which are discussed in the next two subsections.

### 5.2.1 The Pareto-efficient institutional arrangement and Yang Gui's confidence

As our research deepened, we made a discovery about a distinct characteristic of the 1962 agreement via an auxiliary element of the CPR lens—the construct of Pareto-efficiency.

Pareto-efficiency or Pareto-optimality is a concept of efficiency used in economics, operations research, decision science, and political science, named after the Italian economist and sociologist Vilfredo Pareto (1848–1923) (Ingham 2019). In operations research and decision science, it is also called “noninferiority” or “nondominance” (Cohon 1978, pp. 69–72, p. 220). By definition, “[a] social state is Pareto-optimal [Pareto-efficient, noninferior, nondominant] if no individual can be made better off without making at least one other individual worse off.” (Cohon 1978, p.220; where the author Jared Cohon, an American scholar of operations research, also provided a mathematical definition). Pursuing such a state is regarded by many as a way of “providing the healthy resolution to apparent contradiction” [Donham 1990, p. 192 (the quote); McCay 1995, p. 109]. In the CPR literature which we built our theoretical lens on, the concept has been used in defining and measuring the efficiency of institutional arrangements in CPR governance, including irrigation canal governance [see, for example, Dietz et al. (2002, p. 25), Gardener et al. (1990, pp. 336–337), Kopelman et al. (2002 p. 113), Sarker and Itoh (2003, p. 160, p. 166)]. This reported usage naturally aroused our curiosity—

Is the 1962 institutional arrangement Pareto-efficient?

Via this auxiliary component of the CPR lens, we found the answer to be positive. The 1962 institutional arrangement—the coherent set of four provisions in the bilateral agreement—did create a mutually beneficial yet non-static equilibrium, a Pareto-efficient state *at which* the interests of canal users from both counties are delicately balanced and *beyond which* any extra gain of canal users from one county would necessarily lead to a loss of canal users from the other county. As illustrated in Fig. 5, the institutional arrangement achieved this social state of balance by virtue of its four component provisions. Here we saw that the soft, reciprocal power of these mitigation measures was at work just as effectively as the hard, regulating power of theirs. Under these “powerful” provisions, Linxian was granted the permanent privilege to use Pingshun’s land for constructing and operating the canal’s Pingshun segment, including the crucial diversion dam; in return, villages along the Pingshun segment were assured the permanent right to use the canal water, and compensated for their loss of land and properties. Further, through responsibility-sharing, both counties were

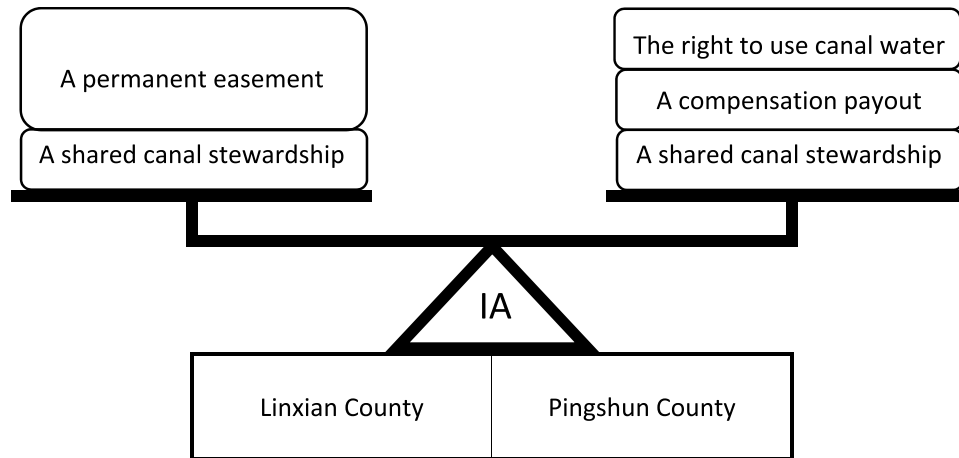
committed to and held accountable for the moral obligation of good stewardship to the Pingshun segment.

This finding further directed our curiosity toward a scenario question: what if Yang Gui were shown the illustration in Fig. 5 and convinced that those “powerful” provisions had created a delicately balanced, mutually beneficial social state of Pareto-efficiency? Would he feel (more) optimistic that the agreement on the four provisions could be readily adopted, instituted, and honored by both counties and therefore be more confident that it could serve the noble goal “to save posterity the trouble”? It is difficult not to say that he would.

### 5.2.2 Moral guanxi practice and Yang Gui's confidence

Another preponderant factor that could have contributed to Yang Gui’s confidence-building is the *moral guanxi practice* that the people of both counties, including their leaders, had been engaged in before and during the agreement-making process. The Chinese noun *guanxi* (i.e., 关系) generally means *a relationship* between objects, processes, or people (Yang 1994, p. 1), and here refers to an interpersonal relationship or “a web of social relationships” (Gold et al 2002, p. 13). *Guanxi practice*, as described by American cultural anthropologist Mayfair Yang in her 1994 “pathbreaking book” *Gifts, favors, and banquets: the art of social relationships in China* [Wellman et al 2002, p. 222 (the quote)], is the reciprocal act and process of cultivating, sustaining, and employing a web of social relationships toward mutually beneficial ends (Yang 1994, pp. 6–7). At the core of this perpetual social practice is a cultural belief throughout Chinese history. That is, the people on such a web of social relationships are members of a community in which the golden rule is to pursue mutually beneficial outcomes through friendship, sharing, and mutual obligation “to give, to receive, and to repay” [*Ibid.*, p.8 (the quote); p.166]. As an instrument for cultivating and sustaining such a community, *guanxi practice* is not inherently good or bad, and may lead to either positive or negative results. We as such add a modifier “moral” here to emphasize that the *guanxi practice* the people in the Red Flag Canal case exercised was positive—to pursue mutually beneficial results for the entire canal community—and in accord with moral principles upheld in their own place and time.

Many instances of moral *guanxi practice* people of the two counties engaged in before and during the agreement-making process have been well documented, thanks to the important work by historians Hao Jiansheng, Sheng Shufeng, Wang Hongmin (王宏民) and Sang Jilu (桑继录) (Hao et al 2011; Sheng 2020; Wang and Sang 1995). One telling example before the agreement-making process is the installation of 24 water gates on the Pingshun Segment (Fig. 6a, b). The Linxian project team provided this pro bono



**Fig. 5** The delicately balanced, mutually beneficial social state of Pareto-efficiency the 1962 institutional arrangement (IA) created between Linxian and Pingshun (see Sect. 1 for descriptions of the four provisions—"the weights" on the scale) [Notes: With this visual illustration, one can imagine various scenarios under a general premise stated in the above main text. The premise, "beyond which [i.e., this balanced social state] the extra gain of canal users from one county would necessarily lead to the loss of those from the other county", implies that a unilateral change of any kind could break the balance. Such changes may include, *inter alia*, an alteration to the

duration of the easement from "permanent" in the existent provision "A permanent easement" (see Sect. 1) to "20-year"; the removal of the words "and guaranteed" from the sentence "villages along the Pingshun segment are entitled and guaranteed to use the canal water for drinking, irrigation, and powering water mills." (in the provision "The right to use canal water", see Sect. 1). Any possible change of that nature would be a balance-breaker to the social state of Pareto-efficiency this institutional arrangement established and could thus serve as a "driver" in one's scenario composition.]

publico service to the Pingshun villagers along the canal and completed before Yang Gui initiated the agreement-making process (Sheng 2020, pp. 123–124; Wang and Sang 1995, p. 148). Inadvertently or otherwise, their act served well the purpose of moral guanxi practice. It offered an olive branch—a goodwill gesture—to the Pingshun people in the hope of cultivating a strong sense of canal community; and the offer was indeed well received by the Pingshun people (*Ibid.*) and might even contribute indirectly to the success of agreement-making process.

Another example of successful moral guanxi practice is the agreement-making process. As presented in Sect. 2, this was a self-initiated, participatory, and codesigning process that produced a fair, workable agreement of which canal users from both counties willingly claimed their coownership. From the vantage point of guanxi practice, agreement-making was nothing but a process of moral guanxi practice to build a canal community that pursues mutually beneficial outcomes through friendship, mutual obligation "to give, to receive, and to repay", and resource sharing. The resulting agreement, with the Pareto-efficient institutional arrangement it instituted, is both a testimony of this successful process and a covenant for sustaining such a practice onward. Thus people's enthusiastic participation in the agreement-making process and their acceptance and support of the

agreement could be interpreted as their willingness to join the newly formed canal community and to honor the golden rule underpinning.<sup>29</sup>

Could these and other instances of successful moral guanxi practice before and during the agreement-making process be yet another source of Yang Gui's confidence in the efficacy of the 1962 agreement? They certainly could.

## 6 The importance and relevance of our endeavor

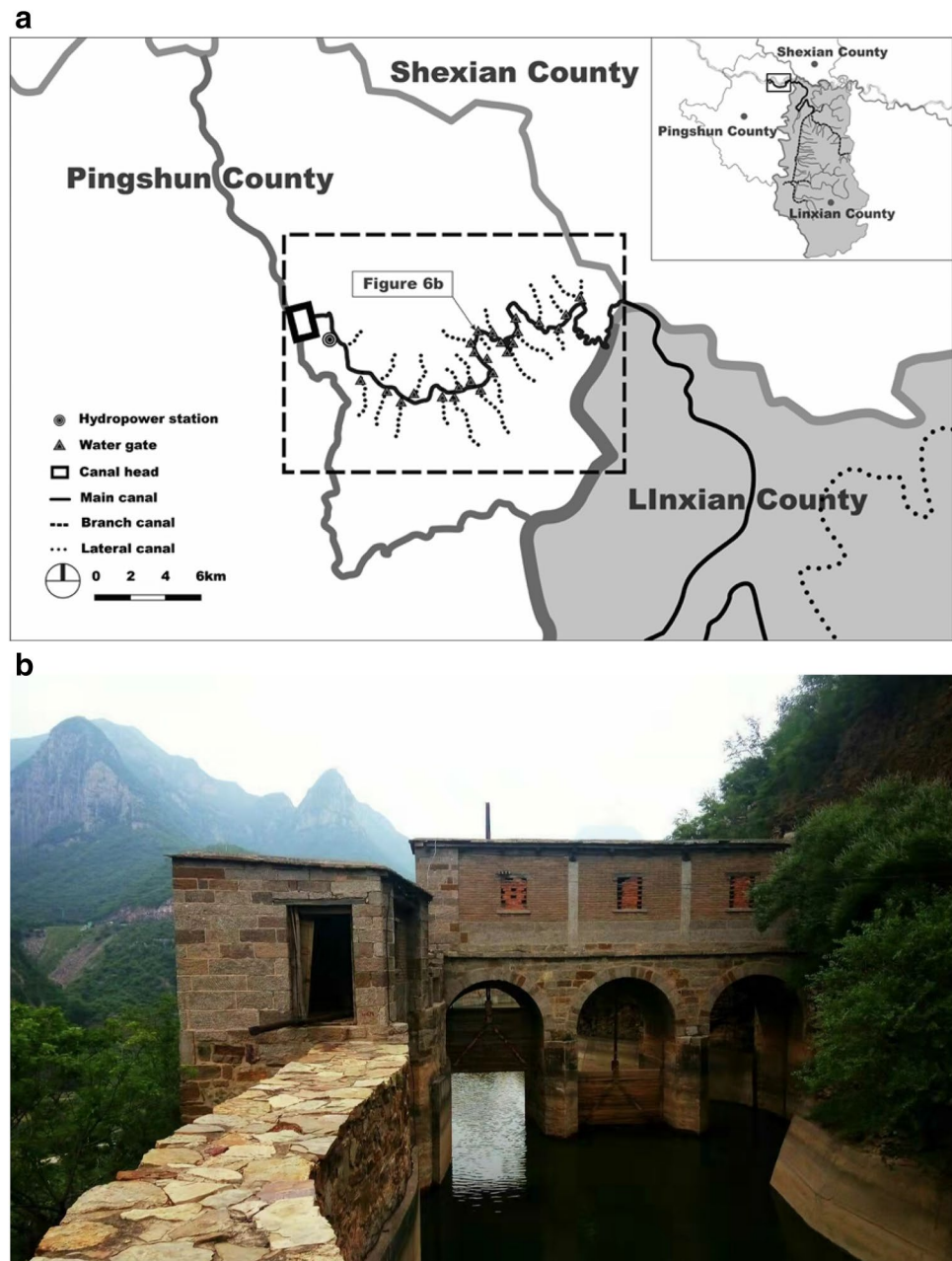
With the closure of the said knowledge gap, the presentation on our endeavor proceeds to an end. Still, readers may have two general questions to ask about this endeavor:

Why is it important to research the 1962 agreement and the agreement-making process? Why is it important to study the people—Yang Gui and his fellow practitioners—in agreement-making?

<sup>29</sup> Moral guanxi practice in the Red Flag Canal project is an important topic for at least two reasons. First, it is an important factor contributing to the success of the project; and second, its focus on the cultural and social aspects in this socio-ecological practice is a highly relevant subject in ecopracticology—the study of socio-ecological practice. As it will be further explored and reported in a separate article, the presentation here is brief and only intended to support the discussion on the third likely source of Yang Gui's confidence.



**Fig. 6 a** The 24 water gates built by the Linxian project team as a pro bono publico service for the villages along the canal's Pingshun segment [These water gates were completed on October 1, 1960; their locations were determined by the Linxian project team in consultation with the villagers (Shen 2020, p. 123) **b**. The water gate near Wangjiazhuang Village (王家庄村), Pingshun County (its location is marked in (a)). The photo was provided by Lu Hongbo (路红波) of Pingshun County Department of Natural Resources. It is used here with his permission



Right on-target to their questions, we found the following passage by Elinor Ostrom that we read while building the CPR lens.

Although the particular problems involved in governing mountain commons vary from those involved in governing irrigation systems, all of these long-enduring institutional arrangements have shared commonalities. These cases clearly demonstrate the feasibility (but obviously not the likelihood) of robust, self-governing institutions for managing complex CPR situations, but the origins of these systems are lost in time. It is not possible to reconstruct how earlier users of

Swiss alpine meadows, Japanese mountain commons, the Spanish *huertas* [orchards], or the Philippine *zanjeras* [irrigation canals] devised rules that have survived such long periods. We do not know who originated or opposed various proposals, or anything about the process of change itself. (Ostrom 1990, p. 103)

We second the comment Elinor Ostrom made here about “shared commonalities.” We believe that the insights we derived from researching the 1962 agreement and the agreement-making process, and discoveries made from studying Yang Gui and fellow practitioners who originated and participated in agreement-making exemplify the body

of knowledge ecopracticology, the study of socio-ecological practice, aims to build [For the five subject areas of ecopracticological knowledge, see Xiang (2019b, pp. 8–9)]. In particular, the rationales and justifications Yang Gui and his fellow practitioners developed and used then and there have shared commonalities with those by practitioners in other instances of CPR governance practice. Once systematically unearthed and critically scrutinized, they will have “the prescriptive power to inform and inspire” contemporary socio-ecological practitioners “to be efficacious and righteous in their practice...” (Xiang 2020b, p. 122). As such, our research findings from this endeavor will significantly enrich the emerging field of ecopracticology, and ultimately help advance contemporary socio-ecological practice.

We also echo the sentiment Elinor Ostrom expressed here and feel obligated not to let “lost in time” and in the international literature the people, the origins, and processes of the Red Flag Canal project. Admittedly, should this reported research be conducted before 2018, we would be able to interview Yang Gui for the three questions raised in Sect. 3, and would not have to use as much subjunctive mood in our article-writing. As time passes by quickly, there is indeed an urgency to document and archive in the international literature the history of the Red Flag Canal, one of the best kept secrets in the history of socio-ecological practice. We shall continue and invite more colleagues to join us in this worthy and time-sensitive endeavor.

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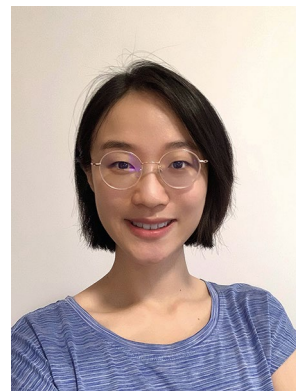
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